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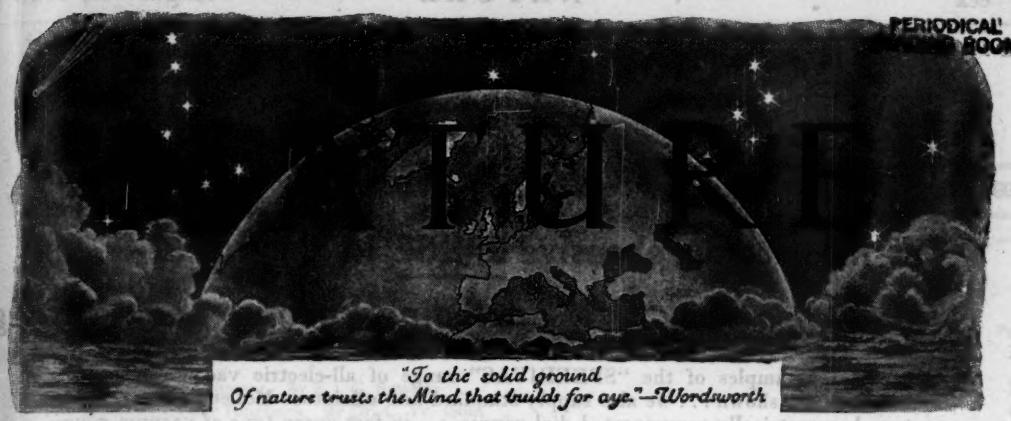

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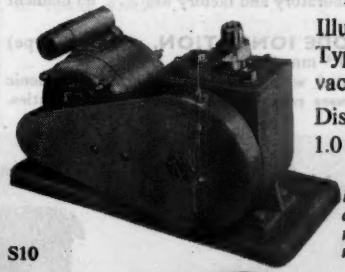

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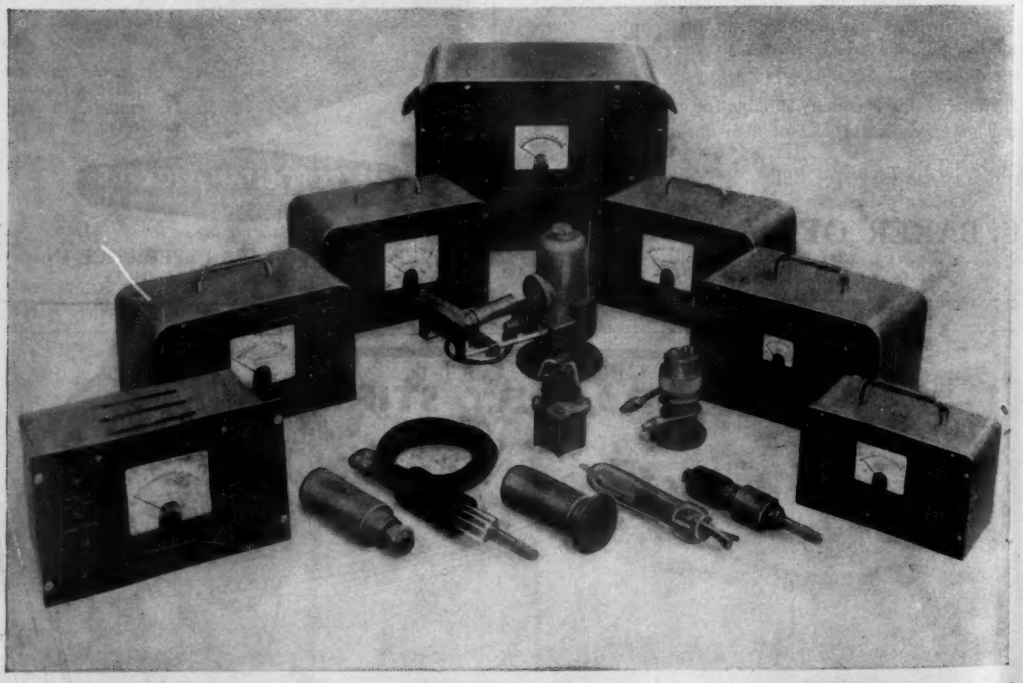

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NATURE

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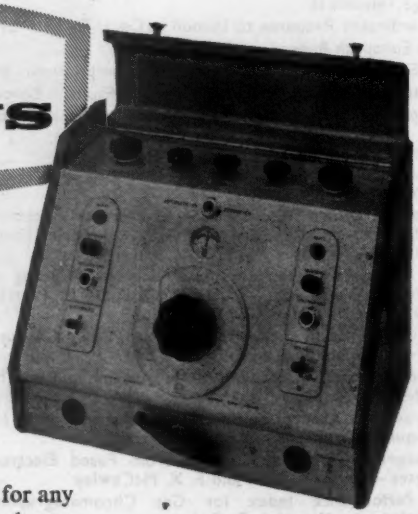

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RESEARCH AND DEVELOPMENT IN NUCLEAR ENERGY

THE third annual report of the United Kingdom Atomic Energy Authority* provides an impressive picture of the many-sided contribution which the work of the Authority is making to Britain's economic development. It does not, however, make possible an assessment of the magnitude of the Authority's demand upon the resources of the country in either man-power or materials. Much of the material in this report will be already familiar to readers of *Nature* from the re-consideration of the nuclear power programme and capital investment in the fuel and power industries which has followed on the success of the Calder Hall station, so that recapitulation seems unnecessary. It should suffice to note that the report provides a convenient and authoritative means of following the progress of events, and to pass on to other matters of scientific and technical interest. The operating account continues to be withheld from publication in the interest of national security, and the balance sheet merely shows an item of £2,691,341 for research and development expenditure in aid of design. It may also be noted that the whole of the cost of operation of the Research Group, less the proceeds of sales of radioactive substances, electronic equipment and other income, is regarded as fundamental research in the nuclear energy field and as such is borne by the Exchequer. Similarly, the cost of operation of the Weapons Group which, besides other research and development, undertakes the production of components for weapons and research work in connexion with weapons, less the amounts chargeable for such work under contract to the Ministry of Supply, is regarded as a charge to be borne by the Exchequer.

On the staff side, the expansion of the Authority continued at a high level, non-industrial staff increasing from 10,795 to 12,630 at March 31, 1957, and industrial staff from 13,178 to 14,660, the greatest difficulties in recruitment being in the more senior posts, especially in engineering. These figures do not, of course, give any accurate indication of the demand on the nation's scientific and technical man-power; but the Authority is making a positive contribution in this field. As a result of a review of its own training facilities in the light of the White Paper on Technical Education, a revised scheme of awards has been introduced to enable selected members of the staff to attend university and 'sandwich' courses. The first bursaries for full-time university courses were awarded in May 1956, and systematic selection of candidates for 'sandwich' courses in technical colleges started in time for the January 1957 term. Besides this, 471 students have already passed through the Reactor School at Harwell, more than 900 students through the Isotope School, and the first course in the school at Calder Hall for training reactor operators for power stations was attended by eight students. Students for these courses, which in future will last six weeks, will be expected to have attended the Reactor School at Harwell or to have reached a comparable standard of knowledge. In addition to the three-and-a-half month full courses at the Reactor School, two short courses, the first of several new courses made possible by the expansion in capacity of the School, have been given to industrial executives with the view of giving senior industrialists a general appreciation of the problems and possibilities of nuclear power. Moreover, to keep industry broadly informed of work in progress which might eventually lead to industrial application, the Authority arranged some ten conferences during the year to which representatives of industry were invited, with the view of acquainting industry with the possibilities that are being examined so that firms may think about applications in their own fields and provide for discussion of the lines of development being followed.

In spite of the steady flow of inquiries from industry, mostly from firms which were unaware of the large amount of published information available, few 'access agreements' have as yet been negotiated. The Authority has also directed the attention of individual firms to inventions of interest in their own particular fields. Apart from inventions of major importance to the nuclear power programme, the Authority now has some 230 inventions protected by patents and patent applications, covering a wide range in the chemical, metallurgical, electronic and instrument fields, and up to the present, thirty-nine patent licences have been granted to British firms and six to firms in other countries. Besides this, as a result of the eighth Tripartite Declassification Conference between the United Kingdom, the United States and Canada, held in the United States early in the year, and ratification of its recommendations, virtually all technological information needed to develop a civilian nuclear power industry, including a very wide range of information on the design, construction and operation of power reactors, together with details of the metallurgy of fuel materials, the fabrication of fuel elements and the effect upon them of radiation, has been freed from security restrictions on publication.

These changes will permit the greatest release of information on nuclear energy since the Conference on the Peaceful Uses of Nuclear Energy at Geneva in August 1955, and the Authority has undertaken to review all existing classified reports to see which can be made available to the public. The more useful of these will be reprinted, and periodical lists will be issued of the others; it will be possible to borrow these from the Authority's libraries. Much else is done by the Authority to disseminate information on nuclear energy both by papers by the Authority's staff in the scientific and technical press, which

* United Kingdom Atomic Energy Authority. Third Annual Report for the period 1st April 1956–31st March 1957. Pp. vi+58. (London: H.M. Stationery Office, 1957.) 3s. net.

during the year numbered 450, and by the issue of lists of new publications acquired by the Authority's libraries, information bulletins and bibliographies on selected subjects. Indeed, it would appear that, within the limits set by official policy, the Authority is already doing all that can reasonably be expected to facilitate the dissemination of technical information in this field, as well as to promote the necessary training of scientists and engineers drawn from British industry and from overseas.

It is, of course, essential that a proper balance should be achieved between national security on one hand and the rapid advance in the peaceful applications of nuclear energy on the other; accordingly it is important that scientists in general should take every opportunity to ensure that the dangers of excessive secrecy are clearly understood, and also the dependence of national security on the positive achievements of technology rather than on any negative measures. This applies to staff no less than to information. The more interlocked with industry the Authority's part in the application of nuclear energy becomes the more essential it is that there should be free movement of staff and of information, and that such movement and interchange should not be hindered by restrictions that cannot be clearly shown on continuous scrutiny to be essential for national security.

This is sufficiently illustrated by the Authority's clear concern with the export of reactors, to which the report refers. Although this is the responsibility of industry, the Calder Hall type of reactor is the only type of power reactor of British design at present available for export from the United Kingdom; and, as its designers and operators, the Authority is well qualified to describe its features and advantages to potential customers. The Authority is also responsible for supplying the fuel elements for reactors of British origin exported by industry, and it has a part to play in the inter-government negotiations required in such transactions.

No overseas orders for British power reactors of British design had been received from overseas up to the end of the year under review, although the A.E.I.–John Thompson Co. had received an order for a Merlin research reactor from the German Land Government of North Rhine–Westphalia, which had also authorized the purchase of a DIDO-type of high-flux research reactor. This development aspect may possibly repay a little further attention, and clearly the more contacts between the Authority and industry are facilitated the more effectively industry will be able to make its full and natural contribution to development, as well as to the reactor research programme and to research and development in general. As regards the reactor research programme, the concept of three successive stages has now been abandoned in favour of a more flexible pattern of development, and while the gas-cooled, graphite-moderated system continues to show even greater potentialities than at first thought, work on the sodium-graphite system continues, a high-temperature zero-energy critical assembly is to be built and good progress is being made with the experimental fast reactor at Dounreay. The technological problems involved in the homogeneous aqueous and liquid-metal-fuelled systems are also being examined, as well as possible systems for surface ship propulsion, in addition to work on the development of the pressurized water reactor for submarine propulsion.

The references in the report to these technological investigations give some idea of the far-reaching influence of the Atomic Energy Authority's work on industrial development. For example, in collaboration with industry, the Research and Development Branch of the Industrial Group is investigating the development of steels for pressure vessels which will operate at higher temperatures and pressures. In work on fast reactor systems, conditions have been established for alloying uranium with chromium which improve the creep strength and minimize swelling on thermal cycling, and for casting the alloy into tubes within close dimensional tolerances. Chemical work on homogeneous aqueous reactor systems has included investigations into the stability of uranium and plutonium solutions at high temperatures and pressures and under high radiation flux, and into the behaviour of thorium oxide slurries, while the trend in development of fuel elements for advanced reactors has been towards ceramic, rather than metallic, elements, because the evidence now available indicates that ceramics may be more suitable for high-temperature operation. Techniques are being developed for fabricating and welding zirconium alloys which possess higher creep-resistance than zirconium itself.

About a fifth of the work at Harwell is devoted to fundamental research, and this work, in particular the study of the physics of solids, has yielded results of wide utility. For example, the behaviour of graphite under neutron irradiation can now be deduced from a knowledge of its crystal structure; this has permitted a correlation between neutron-induced damage and changes in the electrical properties of the graphite. Reactors have made possible the new technique for solid-state studies known as neutron diffraction, in which beams of neutrons are used for exploring the atomic architecture of solids, while a group working on cosmic rays is studying the variation with time in the occurrence of big showers of cosmic-ray particles. Fundamental research in chemistry has included studies of practically all the radioactive heavy elements, while developments in the technique of chemical analysis by neutron activation have led to interesting results in pure as well as in applied chemistry, including a technique used, in the manufacture of transistors, to determine as little as one part of copper in ten thousand million of silicon and also the minute traces of gold in sea-water with an accuracy which has confirmed Haber's conclusion that most of the gold is associated with particulate matter. The Authority is also providing to the Colonial Geological Surveys an improved form of ratemeter, produced by manufacturers of electronic equipment and conforming to a specification laid down by the Electronics Division at Harwell, working

on torch batteries and which has a long life in the field.

If, therefore, it is difficult, on the information available, to assess how far the expenditure on the Atomic Energy Authority is in balance with the national expenditure on research and development as a whole, there can be no question as to the value of the return received from that expenditure. When such an assessment cannot well be made from published information, it is all the more important that the general arrangements should inspire confidence that the assessment is being made within the organization itself and used for guiding policy. For that reason alone it is unfortunate that there is no indication of any intention either to strengthen the staff of the Lord President's office, to provide him at the least with a direct spokesman in the House of Commons, or to fill the office with a Minister whose sole responsibility is to discharge those onerous duties.

There are two further reasons for concern at this delay to deal adequately with the question of the Lord President's responsibilities and with the resources of his office. It is not simply a question of seeing that Britain's research and development effort is in proportion, but also of the division of ministerial responsibilities. The development of an export trade in reactors, which, it is confidently anticipated, might reach the scale of £50 million a year within a decade, involves questions of international trade and relations, and in particular of Britain's position with regard to Euratom and the International Atomic Energy Agency; just as the nuclear power programme is essentially the responsibility of the Minister of Power, but equally is determined by decisions as to the extent of our capital investment made by the Chancellor of the Exchequer. This programme also impinges on that of the use of land generally and, while the desirability of accelerating the execution of the programme cannot be denied, there is reason in the argument of the Council for the Preservation of Rural England that the preparation of a master plan by the Minister of Housing and Local Government is a matter of extreme urgency to prevent the haphazard piecemeal selection of sites.

This third report of the Atomic Energy Authority just touches on two instances which well illustrate this need. The Secretary of State for Scotland has now given his consent to the construction of a 300–320 MW. nuclear power station at Hunterston in Ayrshire; but the delay of nine months between the letting of the contract and the starting of building work means not only a serious interruption of the orderly development of the nuclear power programme, but also that a smaller power station will be built for the same cost than if the Electricity Board had been able to wait until now before settling the details of the contract. It is to the public interest that such delays should be kept to a minimum, just as it is that there should be no over-riding of other interests.

This delay might well be minimized if consent were sought, under such a master plan, at the earliest possible stage. Not only would justice be manifestly seen to be done, but also under a master plan much opposition and obstruction would disappear. It is the piecemeal approach and the fear that the Authority or Ministry is being allowed to judge its own cause that gives rise to legitimate anxiety and opposition. This is equally illustrated by the difficulties that have arisen over the selection of a site for another major research establishment and which led to the introduction of the Winfrith Heath Bill in the House of Commons on May 21, 1957. Despite the care taken by the Authority in the examination of possible sites, the debates in Parliament testify to the weakness in the present procedure and the unnecessary fears that can be aroused; and it is to be hoped that the suggestion thrown out by the Council for the Preservation of Rural England will receive the careful examination it merits.

The chapter on international relations in the present report could not be expected to provide critical comment on the international situation to-day, though it does illustrate its complexity. What is required is that the Government should decide on its policy towards the Organization for European Economic Co-operation in this field, and towards the Euratom countries. It is of the utmost importance that the opportunities opening before Britain in that field, as well as under the Baghdad Pact, are not missed through failure to co-ordinate policy or to place adequate resources at the disposal of those responsible for its execution. Above all is the need for a wide outlook and imaginative approach in place of the piecemeal and haphazard dealing that has caused frustration and waste in the past.

WITTGENSTEIN'S ACCOMPLISHMENT

Philosophical Investigations

By Ludwig Wittgenstein. Translated by G. E. M. Anscombe. (Text in German and English.) Pp. x+232. (1953.) 37*s*. 6*d*. net.

Remarks on the Foundations of Mathematics

By Ludwig Wittgenstein. Edited by G. H. von Wright, R. Rhees and G. E. M. Anscombe. Translated by G. E. M. Anscombe. (Text in German and English.) Pp. xx+204. (1956.) 37*s*. 6*d*. net.

(Basil Blackwell, Oxford.)

THESE two stately volumes (briefly, "Investigations" and "Foundations") are the work of a thinker who is likely as the years go on to stand out more and more distinctly as the possessor of a mind almost without parallel in the long and complex history of philosophical research. At the same time, they manifest the courage and foresight of the publishers in undertaking (whatever the financial arrangements may have been) a task unlikely to appeal to more than a very limited number of readers. Like the "Tractatus" of 1922, the English and German versions are printed on opposite pages, which enables the reader to do two things. These are, first, to get as deeply as possible into the author's mind via his native tongue, and secondly to realize how difficult it is to render into another language ratiocination at this sustained level of spontaneity.

Even so, there are a few instances in which a happier English word could have been chosen without doing any violence to the original, and might, indeed, have added a little to its dignity. But one is grateful all the same for a faithful translation, acceptable in all essentials. As for the editors, they have discharged a most delicate duty with judgment, for the assembling of manuscripts like these, including some and rejecting others, must always be to invite criticism of one kind or another.

The plan of "Foundations" is to present the master's thoughts in five parts, of which Part 1 is largely correlative with portions from the "Investigations". Part 2 deals with the derivability of arithmetic from the calculus of logic. Part 3 contains the necessary preliminary matter for the understanding of the relation between mathematical and empirical propositions, referred to at length in Part 5. In Part 4 come Wittgenstein's speculations on intuitional mathematics, and the law of the excluded middle, while Part 5 includes, among other topics, a somewhat peripheral approach to Gödel's theorem.

Broadly, Wittgenstein is struggling manfully with a problem well-nigh insoluble, namely, the nature of language, and what that nature (if it can ever be fully revealed) permits it to do for the purpose of communication between human beings, both in everyday affairs and in the domain of scientific reasoning. Nobody would expect such an investigation to be more than a sketch within the life-time of an individual however gifted; the reader will nevertheless be fascinated by the author's intellectual humility and sense of failure. If ever two books betoken a pain in the mind, these assuredly do. This leads one to compare these pages with a supreme picture left unfinished by an artist, as if to suggest that—in part, at least—in its incompleteness resides its majesty. Michelangelo's "Entombment" is a case in point: not for a moment could this composition be envisaged as 'finished' without wrecking much of its appeal to our æsthetic sense; and so it is for these intuitive flashes from the brain of Wittgenstein. We are confronted with something akin to a mental workshop, a scene scarcely beautiful at first sight, but capable of almost infinite refinement as its power is recognized. Canon Streeter, some years ago, felt in need for much the same equipment in planning his work on "Reality"; somewhere wherein thoughts could, so to say, be left lying about, in sure trust that they were secure against being tidied away overnight. But this is perhaps a privilege to be claimed in its entirety by genius, and by genius alone.

Wittgenstein's methodology, for example, shows this formative character in its tentative approach. He asks what difference there is between cause and motive, and how these may be discovered. We make no progress by being told what 'motive' is, and what 'judging' is. In other words, attaching a definitive label to the entities under consideration gets us nowhere. More physically, if it is desired to measure a length, the meaning of the word is learnt by learning what the process of measurement involves. Thus, there is both a physical and conceptional connotation attaching to the word 'methodology'. In such a context, it has always seemed to me that the Michelson–Morley experiment stands not only at the apex of ether physics, but that it was also the summit of speculative thought at that particular period. Here, from the point of view of pure epistemology, comes a throw-back, as it were, to that phase of natural philosophy which is not in the least belittled by a negative result. The methodology of physics (like its metaphysics sometimes) is inclined to be a little amateurish: Wittgenstein's broadening of the theory of knowledge in this way should be an additional source of strength as techniques develop.

In the event, mathematicians are considered more as inventors than as discoverers. Queer as this may seem at first sight, it is just this inventive quality which has enabled ratiocination to break through to concepts on the very limits of human endeavour. It has also provided much of the power for the advance in theoretical physics during, say, the past century and a half, if we include the fundamental place occupied by non-Euclidean geometries in cosmology.

With the death of Ludwig Wittgenstein in 1951 ended a career in many respects tempestuous, but full of promise, and (though he would have denied it hotly) of achievement. He has left so much behind for the benefit of mankind. Without qualification, it may be said of him that in thus labouring he entered into his rest. F. I. G. Rawlins

WEBER PARABOLIC CYLINDER FUNCTIONS

Tables of Weber Parabolic Cylinder Functions
Edited by Dr. J. C. P. Miller. Pp. 233. (London: H.M. Stationery Office, 1955. Published for the Department of Scientific and Industrial Research.) 63*s*.

THIS is an admirable example of a scheme which Dr. Miller is well known to favour—a unified analytical and numerical treatment of a particular mathematical function. Systematic study of special functions is now the province of those who make fundamental numerical tables, and this volume, although published separately, is an offshoot of the general activity represented by the British Association and Royal Society Tables Committees.

Weber's equation $y'' + (A - Bx^2)y = 0$ is physically significant in several ways; for example, when parabolic-cylinder co-ordinates are applied to the equation of harmonic waves. With $B > 0$ it can be the Schrödinger equation of a harmonic oscillator. It can occur in approximations to partial differential equations of parabolic type, for example, in boundary-layer theory. Alternatively, it is a third approximation to the general linear equation in its 'normal form' $y'' + I(x)y = 0$, and Section 2 of Miller's introduction examines this aspect. The case where $I(x)$ is linear leads to Airy's equation; the present volume is really a successor to Miller's "Airy Integral" (British Association Tables, Part-volume *B*, 1946).

The standard forms discussed are (1) $y'' - (\frac{1}{4}x^2 + a)y = 0$, and (2) $y'' + (\frac{1}{4}x^2 - a)y = 0$, where the real constant a may be positive or negative. Eighty paags are devoted to the theory of (1) and (2), including (pp. 61–89) an invaluable list of "Functions and Formulæ". The tables (140 pages) unfortunately deal only with (2). An important feature is the correct choice of a standard pair of solutions, which should be 'numerically independent' over a wide range, taking into account that (1) and (2) may exhibit both exponential and oscillatory regions. The tabulated solutions of (2), $W(a,x)$ and $W(a,-x)$, are such that they differ in phase by $\pi/2$ in oscillatory regions and change in magnitude across exponential regions by

the greatest possible amount. Table 1 (84 pages) gives $W(a,x)$ and $W(a,-x)$ on facing pages for $a = -10(1)10$, $x = 0(0{\cdot}1)10$, to about 8 figures. Reduced derivatives for x-wise interpolation by Taylor series are fully tabulated. Various auxiliary functions occupy Tables 2–6 (56 pages), including $\ln W(a, \pm x)$ in exponential regions, and the modulus and phase of $W(a, \pm x)$ in oscillatory regions.

This review is slightly improper, in that I was intimately concerned with some of the basic calculations; but (such is the gestation period of a volume of good mathematical tables) eleven years have passed without my having further contact with the work. I therefore feel impartial in welcoming this production of Scientific Computing Service, Ltd., sponsored by the National Physical Laboratory through its Mathematics Division, the constructive influence of which on this and other table-making projects has been considerable. The volume has been very well printed by H.M. Stationery Office.

C. W. JONES

FOSSIL BRACHIOPODS

Chazyan and Related Brachiopods

By G. A. Cooper. Part 1, Text: Pp. xvi+1–1024. Part 2, Plates: Pp. 1025–1245+269 plates. (Washington, D.C.: Smithsonian Institution, 1956.)

THE publication of a monograph describing a supposedly well-known brachiopod fossil fauna in which sixty-nine new genera and more than six hundred new species are proposed is an occasion for some reflexion on the function of the systematist in the realm of palæontology and the wider world of geology. Theoretically, of course, a palæontologist, like his counterpart in the biological sciences, may indulge in identification and classification without further motive. But in practice he is usually fully aware of the possible consequences of his activities, for it is inevitable that they will, sooner or later, influence decisions on stratigraphical correlation on one hand and inquiries into the processes of evolution on the other. These are purposes which demand the exercise of somewhat different methods in faunal investigations so that only rarely is an attempt deliberately made to provide detailed and pertinent information for both fields of knowledge, and, in his study of "Chazyan and Related Brachiopods", Dr. Cooper is no exception, for he has written what is primarily a stratigraphical guide to the Lower and Middle Ordovician rocks of North America based on comparisons of brachiopod faunas.

In this context, Dr. Cooper has succeeded to such a degree that his study is one of the ablest stratigraphical syntheses deriving from the taxonomic analysis of fossil assemblages yet conceived, a truly remarkable demonstration of the advantages as well as the limitations of correlation by faunal association. Doubtless many stratigraphers will feel alarmed at the prospect of so many new names flooding into Ordovician literature but, relative to the scope of this work, the size of collections and the spectacular success of a sustained etching programme for the recovery of chitinous and silicified shells, his new genera and species are not unreasonably prolific. It is true that exception will certainly be taken by other students of the phylum to some aspects of systematic procedure adopted by him. A few of the genera like *Chaulistomella*, *Apatomorpha* and *Glyptambonites* are, in my opinion, too finely drawn, as are some of the new species, especially those founded on size differences, for no attempt has been made to analyse the supposed differences quantitatively. Nevertheless, these discrepancies are really minor, for the majority of his taxonomic units are surely destined to withstand the test of time, and reference to them is facilitated by well-organized systematic descriptions supplemented by brilliantly executed illustrations.

The most inadequate section is undoubtedly that on evolution. Admittedly, the author had no intention of giving more than a few brief interpretative notes on the morphological development and change exhibited by the faunas he has described, and what comments there are are very instructive. Yet it is not unreasonable to judge them insufficient in view of the abundance and magnificence of material so patiently collected and prepared by the author. Surely the discovery of so many bizarre forms and the possession of what must be reasonably complete samples throughout the ranges of a number of related stocks deserves a more detailed appraisal of evolutionary changes affecting the phylum during those times. It is hoped that some such study is forthcoming; in the meantime, Dr. Cooper is to be congratulated on the completion of the most significant contribution to Appalachian geology since 1859.

ALWYN WILLIAMS

PULSE CIRCUITS AND MULTIVIBRATORS

Elements of Pulse Circuits

By Dr. F. J. M. Farley. (Methuen's Monographs on Physical Subjects.) Pp. viii+143. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1956.) 8*s*. 6*d*. net.

Analysis of Bistable Multivibrator Operation

The Eccles-Jordan Flip-Flop Circuit. By P. A. Neeteson. (Series on Electronic Valves, Vol. 10.) Pp. vi+82. (Eindhoven: N.V. Philips' Gloeilampenfabrieken; London: Cleaver-Hume Press, Ltd., 1956.) 15*s*.

THIS addition to the Methuen series of monographs on physical subjects provides a concise introduction to the principles and use of pulse techniques, and is addressed primarily to physicists and research workers. The fundamental principles of pulse wave-forms and of the use of differentiation and integration techniques are described, together with their application to various valve circuit arrangements. Chapter 3 deals with square-wave generators of the multivibrator and other types; and the next chapter illustrates the various arrangements of trigger circuits, including the classical scale-of-two circuit first described by Eccles and Jordan. Later chapters deal with time bases and pulse amplifiers, concluding with one on applications of these circuits to such fields as radar, television, counters and particle detection. Many of the circuit diagrams in the last chapter contain sufficient description of the valves and components to enable the experimenter to set up the practical arrangements as may be desired.

This handy volume is ideal as an introduction to the subject for research workers and engineers; and, while no attempt has been made to provide a complete bibliography, a short list of useful books and references is appended for readers who wish to pursue the subject in more detail.

Two pulse-operated thermionic devices were described in 1919 and must to-day be regarded as classical advances in electronics technique. Prof. W. H. Eccles and F. W. Jordan, in a paper read before the British Association, described a one-stroke relay: this was a combination of two triodes with resistance coupling which, when operated by a small electrical impulse, changed from one condition of equilibrium to a second, in which it remained until reset by the application of a pulse of the opposite sign. This device is commonly referred to as a 'flip-flop' circuit or perhaps, more elegantly, as a bi-stable multivibrator.

The term 'multivibrator' was, however, more appropriately applied to the device described in the same year by H. Abraham and E. Block. They used a somewhat similar combination of valves, but with capacity coupling, so that the flip-flop action was maintained, and the arrangement became a source of oscillations rich in harmonics, and therefore suitable for frequency measurement.

During the past decade or so, these multivibrator circuits have found wide application in the field of computer development and pulse-counting technique. In the book under notice, the author directs attention to the fact that all previous work on the design of such circuits has considered only the stability of the static condition. Prompted by a practical problem, a thorough investigation of the dynamic behaviour of the bi-stable multivibrator was undertaken and is presented in this book. Consideration is given to the overall sensitivity in relation to valve characteristics; to the triggering speed and to the fundamental principles of design. Some numerical examples have been worked out to illustrate the application of the theoretical treatment, the results of which have been used in the development of special valves for multivibrator operation. The book should be very useful to designers of electronic computers, counters and allied devices.

R. L. Smith-Rose

ATMOSPHERIC ELECTRICITY

Atmospheric Electricity

By Dr. J. Alan Chalmers. Pp. viii+327. (London and New York: Pergamon Press, 1957.) 63*s*. net; 10 dollars.

ATMOSPHERIC electricity, as a subject for research, is passing through a rather difficult transitional stage. No longer really viable as a separate field of study, it has yet to become integrated into meteorology in general, and cloud physics in particular, in a manner which may prove necessary to its future advancement. The electrical behaviour of the atmosphere in fine weather, to which so much effort has been devoted in the past, is now fairly well understood; although there are still interesting problems to be investigated, they are not currently in favour or fashion. Attention is now focused on the thunderstorm, for here the central problems, which are still essentially those which troubled Franklin two hundred years ago, remain unsolved. But recent researches make it increasingly clear that the origin of the electric charge in thunderstorms and the mechanism of the lightning discharge are matters closely associated in clouds with the complex physical and dynamical processes which lead to the development of precipitation, and it seems only sensible that they should be studied in this wider setting. Such an orientation is already perceptible, and one feels that the atmospheric electrician of the future may find it increasingly difficult to manage with occasional self-conscious references to convection, *Austausch* and turbulence as though they were passwords to a secret society. He must break down his resistance to meteorological indoctrination or risk finding himself insulated at infinity with no conducting path either to earth or reality.

The feeling that such a change is almost inevitable is strengthened after reading Dr. J. A. Chalmers's "Atmospheric Electricity", a revised and considerably enlarged version of his book of the same title published in 1949. Although the intervening period has been one of steady consolidation rather than of spectacular new advances, a large number of new papers has appeared, many of which describe work carried out during the Second World War. An up-to-date account of the subject is therefore to be welcomed, and little of the material published up to the end of last year has escaped Dr. Chalmers's attention.

The book opens with a short historical introduction; this is followed by a chapter of some forty pages summarizing basic principles, concepts and known facts which will prove helpful to the newcomer to the subject. Here the author introduces the MKS system of units which he uses throughout the text. The next four chapters, which describe various aspects of the fine-weather field with the proper emphasis on experimental techniques and results, are probably the best in the book. There follow three chapters dealing with point-discharge currents, precipitation currents, and the transfer of charge between the atmosphere and the Earth. Only forty-five pages are devoted to the thunderstorm, including chapters on the lightning discharge and the theories of charge generation and separation; this seems rather inadequate in view of the importance of this part of the subject.

The treatment throughout is sound and clearly written, and will be useful both as a text-book and a source of reference. But I feel that some topics might have been discussed in greater depth and in more detail. It is a pity that the author has divided the text into so many short paragraphs numbered serially throughout the book. The frequent appearance of heavy black headings, often three on a page, frequently breaks the flow in the argument, and gives the whole text the appearance of an expanded card index. There are times when Dr. Chalmers leans too far towards impartiality in mentioning every paper which bears some relation to the topic under discussion. For the benefit of his less-experienced readers one wishes he had been less modest in expressing his opinions of the work he describes so clearly. In being kind to everyone he has been less than fair to himself.

The book is well produced, has a good index and a splendid bibliography of some 600 papers (including titles), but even at present-day values its price is much too high.

B. J. Mason

GAS CHROMATOGRAPHY

By N. H. RAY
Research Department, Alkali Division, Imperial Chemical Industries, Ltd.

ONE of the most outstanding advances in analytical chemistry in recent years has been the development of gas chromatography. Realization of the great power and versatility of this technique has resulted in a very high rate of progress, and it is already becoming difficult to keep abreast of all the publications in the field. The intention of the present article is to give a general outline of the methods used in gas chromatography, and to indicate the types of problem for which it is most useful.

Gas chromatography is a method of separating mixtures of gases or volatile liquids by causing them to traverse a column packed with absorbent, in which repeated distribution occurs between the moving gas phase and the stationary phase, which can be either solid or liquid.

Since the moving phase, being a gas, has a low viscosity, it is quite feasible to use very long columns (often up to 12 ft.); and because diffusion in the moving phase is rapid, high rates of flow may be used without loss of efficiency. It is therefore possible in a reasonable time to achieve separations which would require many hours by any alternative method, such as fractional distillation.

For the purpose of discussion, it is convenient to divide gas chromatographic columns into two types: adsorption columns, in which the stationary phase is a solid such as active charcoal; and partition columns, in which the stationary phase is a comparatively involatile liquid, such as a silicone oil, supported on a porous material such as kieselguhr. In both types of column the moving phase is an inert gas, usually nitrogen, which carries the sample to be analysed into and through the column in the form of gas or vapour. Connected to the outlet of the column is a device, such as a thermal conductivity gauge, which can be made to indicate or record the concentration of the constituents of the sample in the exit gas.

The volume of carrier gas which has to be passed through the column to elute each substance in the chromatogram is referred to as the retention volume of the substance; as in liquid chromatography, this is characteristic of the substance in a given column at a given temperature, and provides a method of identification.

Adsorption Columns

The materials employed for the stationary phase in gas adsorption columns are strong adsorbents like charcoal and silica gel. Because the majority of gases and vapours exhibit curved adsorption isotherms on these adsorbents, the straightforward elution of samples from an adsorption column results in the production of unsymmetrical zones, in which usually the leading edge is sharply defined and the trailing edge diffuse. This effect is the more serious, the more strongly adsorbed the substance, and the longer the column (Fig. 1). For this reason, accurate quantitative analysis by this method is only feasible with short columns, or when the substance concerned has a small retention volume, so that the amount of material in the tail of the zone is small enough to be neglected. In spite of this, straightforward elution from a column of adsorbent has been used with considerable success in the analysis of gas mixtures containing hydrogen, nitrogen, carbon monoxide and the lower paraffins[1]; mixtures of paraffins and olefines as far as butane[2]; and mixtures of hydrogen, methane and nitrous oxide[3].

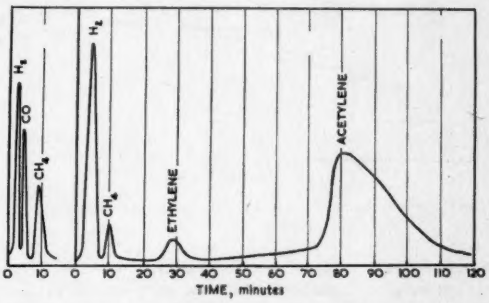

Fig. 1. Elution of gas mixtures from charcoal. (Reproduced by courtesy of the *Journal of Applied Chemistry*)

The accuracy of quantitative analysis by the elution method cannot be improved by increasing the sample size beyond certain limits, due to overlapping of the zones of the chromatogram; for the same reason, the method is unsuitable for detecting a small amount of an impurity in a gas unless there is a big difference between their retention volumes. Much greater accuracy can be achieved, and very low concentrations of impurities can be detected by the use of the displacement technique which was introduced by Claesson in 1946[4]. In this method, which is only applicable to adsorption columns, the constituents of the sample are displaced successively from the column by means of a displacer vapour, which is carried on to the column continuously at constant concentration in the carrier gas stream. The substance chosen for the displacer must be more strongly adsorbed by the packing than any of the components of the sample.

In this type of chromatogram, each substance or group of substances occupying one zone is displaced from the adsorbent at constant concentration by the next more strongly adsorbed substance, and the most strongly adsorbed component is displaced by the displacer. The resulting chromatogram consists of a series of steps, the heights of which correspond to the concentration of material in each zone, which is constant under the conditions of a displacement chromatogram; while the lengths of the steps are proportional to the amount of each substance present (Fig. 2). Increasing the amount of sample does not increase the amount of overlap between adjacent zones in this type of chromatogram and very high quantitative accuracy can be achieved. Even trace amounts of impurities in a gas can be detected in this way by running a large enough sample through a sufficiently long column[5], but the time required for the analysis is increased proportionately.

By combining adsorption chromatography with a chemical absorbent, it is possible to reduce consider-

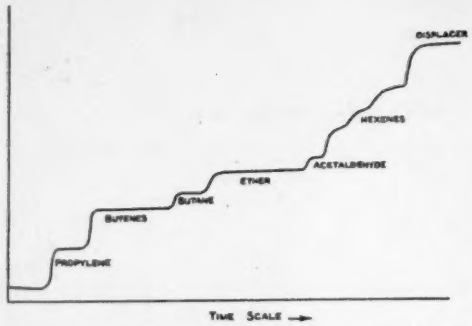

Fig. 2. Resolution of a mixture by displacement analysis from a charcoal mixture

ably the time required for the measurement of trace impurities; if a suitable reagent can be found that will preferentially remove the major constituent of the sample, the residual gases can then be separated and measured on a very much shorter column. The determination of saturated impurities in ethylene has been accomplished in this way, using bromine supported on charcoal to absorb the ethylene[6].

Partition Columns

In a partition column, the absorbent is a liquid, which can often be specially chosen to suit the particular separation it is intended to carry out. Subject to the over-riding consideration that the chosen liquid must have a negligible vapour pressure at the temperature employed (normally a temperature close to the boiling point of the most volatile constituent of the sample), there is a wide variety of liquids which can be used: liquid paraffin, silicone oil, glycerol, and esters of high boiling point, such as dinonyl phthalate, have all been used for a large number of separations. For special purposes the properties of the stationary phase can often be modified advantageously by the inclusion of a solute; for example, in the separation of a series of fatty acids, a 10 per cent solution of stearic acid in silicone oil has proved very successful[7]; and the separation of paraffins from olefins can be greatly improved by taking advantage of the specific interaction between silver ions and the double bond, using as stationary phase a solution of silver nitrate in glycol[8].

The selected liquid is held in the column by supporting it on a porous solid. Originally kieselguhr was used for this purpose, and it is still one of the most popular supports; it is capable of holding up to 30–40 per cent by weight of liquid phase.

More recently a powdered furnace brick ('Sterchamol') has been employed with considerable success[9]; it is coarser than kieselguhr, and the pressure drop through it is lower for a given gas-flow rate. At very high temperatures, salt has been used as the support for the stationary phase[10].

The solid support is impregnated with the liquid absorbent by thorough mixing, which can generally be facilitated by diluting the liquid with a volatile solvent and afterwards evaporating the latter from the paste; the result should be a reasonably free-flowing powder. This is packed as uniformly as possible into the column, which for best results should consist of long straight tubes joined together to form a compact U or W shape (Fig. 3). It is necessary to heat the column to an appropriate temperature for each analysis; this is usually a temperature close to the boiling point of the most volatile constituent of the sample, although satisfactory analyses can be carried out at temperatures much higher than this, as, for example, in the analysis of mixtures of normally gaseous hydrocarbons in a column at room temperature[3]. Since retention volumes in a partition column are very sensitive to temperature, it is important to control the temperature precisely, and for this reason it is a common practice in laboratory work to use vapour jackets for heating; however, most commercially manufactured instruments use electrical heating controlled by a thermostat.

The sample to be analysed may be introduced on to the column either as a liquid or as a gas. The introduction of liquid samples is very conveniently carried out by means of a micrometer syringe, the hypodermic needle being inserted through a rubber serum cap at the beginning of the column. Gas samples may be introduced in a similar manner with the aid of ordinary 5- or 10-ml. hypodermic syringes with well-greased pistons; but greater precision in measuring the sample may be obtained by the use of a short tube of known volume, connected to the column, which can be swept through by the sample and then by the carrier gas, by an arrangement of three-way taps. The small size of the sample (0·5–10 microlitres of liquid, or 1–10 ml. of gas) makes it rather difficult to introduce an exactly predetermined amount, and for this reason internal standards are sometimes employed.

The chromatogram produced on a partition column consists of a series of peaks, which ideally should be symmetrical and similar in shape to a normal error curve (Fig. 4). The position of each peak in the chromatogram is characteristic of the substance concerned in a given column at a fixed temperature, and the constituents of an unknown mixture can be identified by comparison of their retention volumes with those of known compounds on the same column; by the use of two or more columns with different stationary liquid phases, the identification of unknown compounds can be greatly simplified[11].

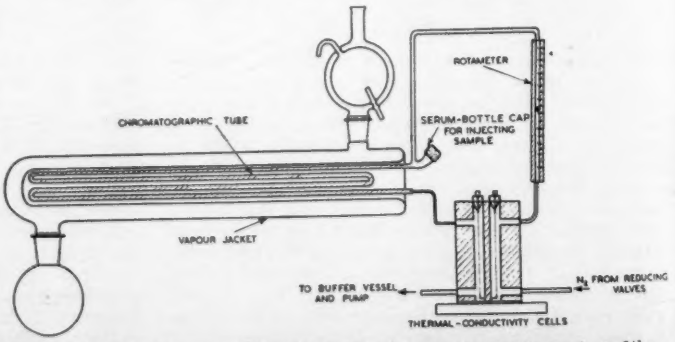

Fig. 3. Apparatus for gas partition chromatography. (Reproduced by courtesy of the *Journal of Applied Chemistry*)

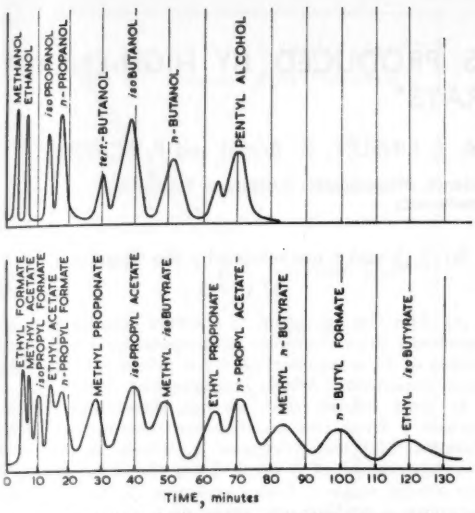

Fig. 4. Resolution of mixtures on a partition column. (Reproduced by courtesy of the *Journal of Applied Chemistry*)

The total area under each peak is proportional to the quantity of the substance present, which can thus be estimated by any of the usual methods. Since in many cases, particularly at the beginning of the chromatogram, the peaks are very narrow, it is often sufficient to measure peak heights; calibration is carried out with known quantities of the substance in question under similar conditions, and an average reproducibility of the order of 1 per cent may be expected in favourable circumstances. A very wide range of compounds can be analysed by gas partition chromatography; the method has been successfully employed for the separation and estimation of hydrocarbons, both aliphatic and aromatic[12], halogenated hydrocarbons[13], including fluorinated compounds[14], alcohols, esters, fatty acids[7], amines and pyridine homologues[11].

Detectors for Gas Chromatography

In both gas adsorption and gas partition chromatography it is necessary to have at the exit of the column a device which is capable of indicating or recording the concentration of the substances present in the chromatogram. A number of such devices have been developed; the earliest, used for the estimation of volatile fatty acids, was the automatic titration cell designed by James and Martin[7]. This detector is of limited applicability, but being an integrating device it possesses advantages over the more usual differential type in quantitative work. Probably the most popular detectors are hot-wire thermal conductivity cells; these are usually employed in pairs, and measure the difference in thermal conductivity between the carrier gas and the column exit gas, so as to compensate to some extent for variations in flow rate. Thermal conductivity cells based on thermistors are used in one of the commercially available instruments for gas chromatographic analysis[15].

The thermal conductivity detector is not sufficiently sensitive for the accurate measurement of minor constituents of mixtures without overloading the column with sample, and a number of other detectors have been developed with the object of providing increased sensitivity. The gas density balance designed by James and Martin[16] responds to minute changes in the density of the column exit gas, and is considerably more sensitive than a thermal conductivity cell; it is somewhat more difficult to construct, however, and is also sensitive to temperature fluctuations. This detector is also available in a commercial gas chromatographic analysis apparatus[17]. The hydrogen flame detector of Scott[18] depends upon the use of hydrogen as the carrier gas; the gas issuing from the column is burnt at a jet, and just above the tip of the flame is placed a thermocouple. The presence of organic compounds in the gas increases the height of the flame, which engulfs the thermocouple. The response is linear over a wide range, and the detector is particularly suitable for the analysis of hydrocarbons, since their heats of combustion per unit weight are all very similar, and thus a single calibration can be used. There are two detectors which depend upon ionization of the column exit gas; in one of these, due to Boer[19], a capsule of radioactive strontium is used to ionize the gas by β-ray emission; a potential is applied between two electrodes in the gas and the ionization current is measured. In the other, due to Ryce and Bryce[20], a portion of the column exit gas is passed through a thermionic ionization gauge and the resulting current is measured. By using for the carrier a gas such as helium, which has a very high ionization potential, it is possible to achieve extremely high sensitivity with this device.

Conclusion

Gas chromatography is a relatively simple process to carry out, yet it provides rapid and efficient separations of a very wide range of compounds. By the use of columns running at high temperatures, even substances with very low vapour pressures can be separated and determined, provided they are sufficiently stable to heat. For analytical purposes, only very small samples are required, and if necessary the sample can be recovered after the analysis; on a preparative scale, large columns are needed, but it is feasible to construct apparatus to deal with amounts up to 10 gm. Finally, it should also be pointed out that gas chromatography is potentially a very powerful tool in physical chemistry, where it can be used for the determination of distribution functions and adsorption isotherms.

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AN EXPERIMENT ON AIR SHOWERS PRODUCED BY HIGH-ENERGY COSMIC RAYS*

By Drs. G. CLARK, J. EARL, W. KRAUSHAAR, J. LINSLEY, B. ROSSI and F. SCHERB

Department of Physics and Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Massachusetts

Size, Spectrum and Atmospheric Absorption

The quantities of interest here are best described in terms of the functions $S(N,x)$ and $N(E,x)$. $S(N,x)$ is the 'integral size spectrum' of all showers observed at the atmospheric depth x; in other words, $S(N,x)$ $A\,d\omega$ is the number per unit time of showers with more than N particles the axes of which lie within the solid angle $d\omega$ and intersect perpendicularly the area A. $N(E,x)$ represents the number of particles in a shower that develops from a primary particle of energy E through a thickness x g cm.$^{-2}$ of atmosphere. In our discussion we neglect fluctuations, and represent the development of all showers by their average behaviour. To our knowledge a satisfactory treatment of the fluctuation problem is still lacking.

The atmospheric thickness x is measured in the direction of the shower axis; thus for a shower coming at the zenith angle θ, x is related to the vertical depth x_0 by the equation: $x = x_0/\cos\theta$. We assume that N depends on the atmospheric thickness x thus defined, but does not depend explicitly on θ; that is, we assume that for a given total mass of air traversed, N is independent of the distribution of the air density along the path of the shower. This assumption appears to be well justified even though it is not rigorously correct, because the density distribution has an effect on the contribution of unstable particles to the development of the shower.

From our experimental results we wish to determine (*a*) the dependence of S on N at x, and (*b*) the dependence of N on x. The analysis is complicated by the fact that if we wish to make full use of the experimental information, we cannot treat problems (*a*) and (*b*) separately. However, it turns out that we need only an approximate knowledge of the dependence of N on x to determine accurately the size spectrum $S(N,x)$. Thus we can proceed by successive approximations.

For a preliminary analysis of the results we assume that N depends exponentially on x:

$$N(E,x) = N(E,x_0)\exp\left(-\frac{x-x_0}{\lambda}\right) \qquad (2)$$

where λ is a constant; we assume further a power-law dependence of S on N:

$$S(N,x) = \left(\frac{N_0}{N}\right)^{\gamma} S(N_0,x) \qquad (3)$$

where N_0 is some convenient reference size.

On these assumptions it can be shown that:

(*a*) S is also an exponential function of x so that:

$$S(N,x) = \frac{K}{N^{\gamma}}\exp\left(-\frac{x-x_0}{\Lambda}\right) \qquad (4)$$

where K and Λ are constants;

* Continued from p. 356.

(*b*) λ, Λ and γ are related by the equation:

$$\Lambda = \lambda/\gamma \qquad (5)$$

(*c*) The size spectrum of showers coming from all directions (and therefore corresponding to different values of x) is represented by a power law with the same exponent γ which characterizes $S(N,x)$.

It then follows that we can determine the exponent γ from the number-size distribution of all showers, and the thickness Λ, which characterizes the dependence of S on x, from the dependence on the zenith angle. Using equation 5, we can then compute a preliminary value of λ.

For the final determination of the spectrum, we proceed as follows. Using the approximately known value of λ, we compute the equivalent vertical size $N(x_0)$ of each observed shower, namely, the number of particles which would have been present in the shower had it come from the vertical direction. Since most showers come from small zenith angles, and since, in any event, we disregard showers with zenith angles greater than 30°, the overall result is not sensitive to the exact value of λ. Having reduced all showers to equivalent vertical sizes, and having computed for each equivalent vertical size the effective solid angle and the effective area of detection, we can construct the size spectrum at x_0 with an accuracy which is essentially limited only by statistical fluctuations and by the instrumental errors in the determination of N.

Figs. 8 and 9 summarize the results obtained from a partial analysis of the observations collected in the course of three consecutive experiments, characterized by different selection criteria (No. 1: more than 17 particles in three or more of detectors C, E, M; No. 2, same for detectors C, M, D; No. 3: same for detectors C. D: see Fig. 1).

Fig. 8 is obtained from the observations on the dependence of zenith angle of showers observed in experiments Nos. 1 and 2. The abscissa represents the difference between the atmospheric depth $x = x_0/\cos\theta$ and the vertical depth at sea-level x_0. The ordinate is the logarithm of the number of showers for which x lies between x and $x + \Delta x$, divided by the solid angle corresponding to the depth interval Δx. Within the statistical errors, the experimental points corresponding to the two experiments lie on straight and nearly parallel lines. This confirms the approximately exponential dependence of S on Λ (equation 4). Moreover, since the mean sizes of showers in the two groups of observations differ from one another by a factor of about 10, we conclude that the characteristic thickness Λ does not change rapidly with N. For the purpose of further analysis we take for Λ the value: $\Lambda = 95$ gm. cm.$^{-2}$. This selection is based both on our results and on the results on the altitude variations and barometric coefficients of air showers obtained in other experiments[2].

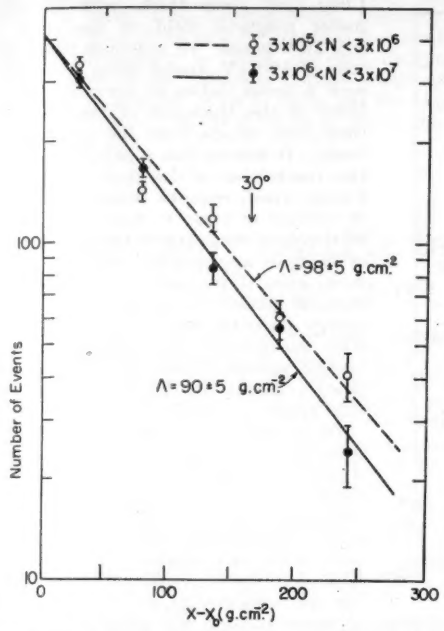

Fig. 8. Plot of observations on the atmospheric attenuation of showers obtained from the distribution of zenith angle

A preliminary analysis of the shower size distribution yields $\gamma = 2$. Thus, for the conversion of showers to equivalent vertical sizes, we use $\lambda = 190$ gm. cm.$^{-2}$. The estimated uncertainty in this value amounts to about 30 gm. cm.$^{-2}$.

Fig. 9 summarizes our present results on the size spectrum as obtained from a combination of the data supplied by the three experiments mentioned above. An important step of the analysis is the precise definition of an 'acceptance area' for showers of each size. This area is chosen so as to ensure that any shower the centre of which lies within its boundaries has practically 100 per cent probability of triggering the recording system. The results are presented in the form of a differential spectrum. The abscissa is the logarithm of N, and the ordinate is the logarithm of $s(N,x_0)$, where $s(N,x_0) = \frac{\partial S(N,x_0)}{\partial N}$. (The actual plot was made as follows. For each vertical shower size we computed a weight factor W representing the reciprocal product of the effective solid angle and effective area of detection. We then divided the abscissa N into equal logarithmic intervals. For each interval, ranging from N_1 to N_2, we computed the sum of the quantities W relative to all observed showers falling within this interval, and divided this sum by $N_2 - N_1$. We took this quantity to represent $s(N)$. We choose the corresponding abscissa, $\overline{N}$, to satisfy the equation: $\frac{1}{\overline{N}^\gamma} = \frac{1}{N_2 - N_1} \int_{N_1}^{N_2} \frac{dN}{N^\gamma}$.)

The quantity $\frac{\partial S(N,x_0)}{\partial N}$ represents the rate of arrival (per cm.^{2} and steradian in the vertical direction) of showers with N particles. We see that within the limits $10^6 < N < 10^8$ the differential spectrum may be closely approximated by a power function of N, with a negative exponent of $2{\cdot}84 \pm 0{\cdot}15$. The corresponding integral spectrum is represented by the equation:

$$S(N,x_0) = (3{\cdot}8 \pm 1{\cdot}2) \times 10^{-12} \left(\frac{10^6}{N}\right)^{1.84} \text{cm.}^{-2}\,\text{sec.}^{-1}\,\text{str.}^{-1} \quad (6)$$

This result agrees satisfactorily with our preliminary estimate of the shape of the spectrum.

The intensity given by equation 6 for $N = 10^6$ agrees reasonably well with the value of $5{\cdot}5 \times 10^{-12}$ cm.$^{-2}$ sec.$^{-1}$ str.$^{-1}$ found by Greisen from a detailed analysis of measurements of the density spectrum of showers[2] (that is, the rate at which a detector records a local density of shower particles exceeding a given value). However, the size spectrum obtained from an observed density spectrum is reasonably accurate only if (1) the shape of the lateral distribution function at small distances from the shower core does not change with shower size, and (2) the size spectrum can be represented by a power law with a very slowly varying exponent. The observed form of the density spectrum will not reveal the details of any sudden deviation of the size spectrum from such a power law. The present experiment with its good size resolution indicates the absence of any deviations up to $N = 10^8$ particles.

Energy Spectrum of Primary Cosmic Ray Particles

We probably have not introduced serious errors into the analysis of the results for the size spectrum by neglecting the effect of fluctuations in shower development. On the other hand, the proper conversion of the size spectrum into a primary energy spectrum would require a careful consideration of fluctuations. For the time being, however, we shall

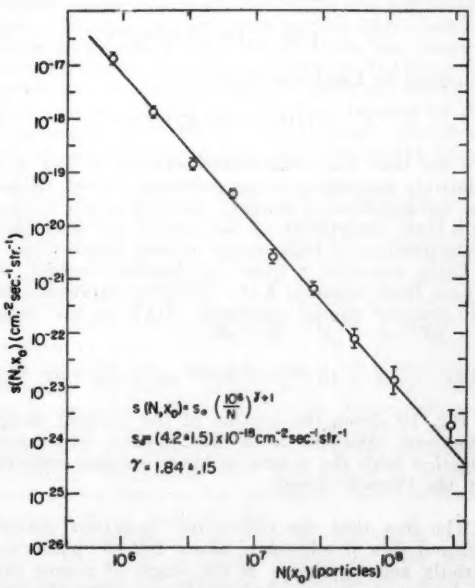

Fig. 9. Differential size spectrum of showers at sea-level in the vertical direction

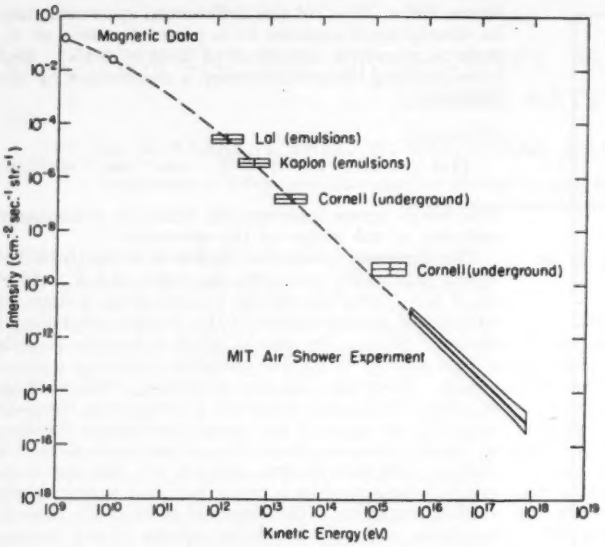

Fig. 10. Plot of the combined results from several experiments on the integral energy spectrum of primary cosmic rays

neglect fluctuations, with the realization that this neglect may lead to a systematic error in the evaluation of the primary intensity, and will smear the details of any sudden changes in the primary spectrum that may exist.

S. Olbert has computed the function $N(E,x_0)$ using both the Fermi and the Landau models of high-energy nuclear interactions[4]. Assuming complete inelasticity and a collision mean free path of 100 gm. cm.$^{-2}$, he has obtained:

according to Fermi's model:

$$N = 1{\cdot}80 \times 10^5 (E/10^{15})^{1{\cdot}10} \quad (7)$$

according to Landau's model:

$$N = 1{\cdot}10 \times 10^5 (E/10^{15})^{1{\cdot}16} \quad (8)$$

We see that the relationship between N and E is relatively insensitive to the particular model. Hence the computation of primary energies is not subject to a large uncertainty on account of our incomplete understanding of high-energy nuclear interactions.

Using equation 8 based on Landau's model, we obtain from equation 6 the following expression for the integral energy spectrum, $J(E)$, in the range 4×10^{15} eV. $< E < 10^{18}$ eV.:

$$J(E) = 2{\cdot}2 \times 10^{-10} (10^{15}/E)^{2{\cdot}13} \text{ cm.}^{-2} \text{ sec.}^{-1} \text{ str.}^{-1} \quad (9)$$

Fig. 10 shows the portion of the integral energy spectrum obtained from the present experiment together with the results at lower energies collected by the Cornell Group[5].

The fact that the cosmic-ray spectrum extends without sign of a break to about 10^{18} eV. places any strictly galactic theory of the origin of cosmic rays under severe strain. Indeed, if we accept the conventional description of the galaxy as a disk about 1,000 light years thick, with an interstellar magnetic field of the order of 5×10^{-6} gauss, we conclude that protons of 10^{18} eV. travel along trajectories with a mean radius of curvature of the order of the thickness of the disk, and thus must escape from the galaxy quite freely. It follows that a galactic acceleration mechanism of the kind suggested by Fermi, which requires times of the order of millions of years to double the energy of the particles, cannot produce protons of energies approaching 10^{18} eV. Moreover, even if we grant the existence of suitable galactic sources of such high-energy particles, we would still be faced with the difficulty of explaining why the energy spectrum does not drop sharply when trapping by the galactic magnetic field ceases to be effective.

Of course, we cannot discount the possibility that large showers may be produced by heavy nuclei, the magnetic rigidity of which is smaller than that of protons of the same energy by a factor equal to the nuclear charge. Even so, however, it begins to appear that some modification of the conventional views regarding the structure of the galaxy and the conditions of space outside the galactic disk may become necessary. The least drastic revision would be the assumption of a nearly spherical galactic halo of highly turbulent diluted gas carrying magnetic fields not much weaker than those existing in the galactic disk. This halo (for which there seems to be some astronomical evidence) would then replace the galactic disk as the confining volume for cosmic rays. Cosmic ray particles, escaping from the disk, could be brought back to it perhaps after having gained most of their energy while travelling through the halo.

The above considerations clearly indicate the crucial importance of further experiments. It will be particularly interesting to see whether or not the anisotropy at the highest energies which our preliminary results suggest will be confirmed. What is known about the magnetic field of the galaxy seems to indicate that this field has an irregular local structure but follows a fairly regular pattern in its average distribution. Hence even in the presence of a galactic halo, particles with trajectories insensitive to the small-scale irregularities of the field might exhibit some anisotropy related in a simple manner to the location of the sources and to the large-scale structure of the field. Also the spectrum should not extend much beyond 10^{18} eV. without a marked change in its logarithmic slope.

If this change does not occur, and if isotropy subsists well beyond 10^{18} eV., we may be forced into the assumption of an extragalactic origin of high-energy cosmic rays. This assumption would not be unacceptable on energy grounds, for the high-energy tail of the cosmic-ray spectrum carries only a very small fraction of the total cosmic-ray energy. However, it might be taken as an indication of the existence in intergalactic space of variable magnetic fields capable of accelerating cosmic-ray particles.

We acknowledge the essential contributions made by P. Bassi and M. Oda to the early planning and

development of this experiment. Many others associated with the Massachusetts Institute of Technology have given us their generous co-operation. We wish particularly to thank Harvard University and the staff of the Harvard College Observatory for making it possible for us to carry out the experimental observations on the grounds of the George R. Agassiz Station.

This work has been supported in part by the joint programme of the Office of Naval Research and the Atomic Energy Commission, and in part by the National Science Foundation.

[4] Part of Olbert's theory will appear soon in *Annals of Physics*. We are greatly indebted to Dr. Olbert for making his unpublished results available to us.

[5] Barrett, P. H., Bollinger, L. M., Cocconi, G., Eisenberg, Y., and Greisen, K., *Rev. Modern Phys.*, **24**, 133 (1952).

UNIVERSITY COLLEGE OF RHODESIA AND NYASALAND

INSTALLATION OF THE QUEEN MOTHER AS PRESIDENT

ON the morning of July 5, almost four years after H.M. Queen Elizabeth the Queen Mother had laid the foundation stone of the University College of Rhodesia and Nyasaland, she was installed as its first president at a ceremony held in the College amphitheatre. The plans for, and the development of this College, situated in Salisbury, Southern Rhodesia, and by its charter of a multi-racial character, have been referred to in the columns of *Nature* from time to time (*Nature*, **172**, 1 (1953); **173**, 1007 (1954); **175**, 181 (1955); **179**, 612 (1957)). This important new venture received a most significant stimulus when Her Majesty accepted the post of first president of the College.

In her speech after installation, the Queen Mother referred to the setting up of a university institution in this part of Africa, which had been in contact with Western civilization for so short a time, as "a striking act of faith". In her own words, "To insist that the College from its inception should aim at the highest academic standards and should open its doors to all who are qualified to enter, regardless of race or colour, is a great challenge. I am persuaded, however, that this act of faith will be justified and this challenge successfully met because the College, by the very boldness of its conception, is in the pioneering tradition of this country—a tradition of which the supreme example is the life and service of Cecil Rhodes".

The College early took the decision to embrace special relationship with the University of London (see *Nature*, **175**, 181; 1955), and so the degrees to be taken by the undergraduates of the University College will be those of the University of London. In her speech at her installation, Her Majesty, who is both president of the College and chancellor of the University of London, was therefore able to say: "The Chancellor of the University of London is delighted to be able to inform publicly the President of the University College of Rhodesia and Nyasaland that the special relationship which exists between the two institutions is 'Twice blest, It blesseth him that gives and him that takes'."

At the installation ceremony there were present representatives of fifteen universities of the United Kingdom, in addition to twenty-four from other parts of the Commonwealth. Fourteen universities and colleges in other parts of the world were also represented, including eight from the United States of America. Many of the representatives presented addresses of congratulation to the Queen Mother as president of the College on behalf of their university institutions. The universities in the Union of South Africa have naturally been especially interested in the development of a multi-racial university college in a territory so close to their own and, as the Queen Mother pointed out in her address, it was an imaginative and graceful gesture on the part of the University of Cape Town to present to the University College of Rhodesia and Nyasaland the presidential robes which she wore on the occasion of her installation. The Queen Mother asked that the representative of the University of Cape Town, its chancellor, the Hon. Albert van de Sandt Centlivres, would take back to his colleagues a message of grateful thanks from the College.

The University College of Rhodesia and Nyasaland stands on rising ground, three to four miles to the north of the centre of the city of Salisbury in an area known as Mount Pleasant. The area of the site is 474 acres and it was given by the City of Salisbury for the purpose. The general layout of the University buildings was prepared after consultation in 1954 with Sir William Holford, and afterwards the buildings have been planned by one or other of three firms of architects. At the present time one wing of the Arts building has been erected and contains a large entrance hall, classrooms and a lecture theatre. It also houses rooms for the teaching staff, senior common room, administrative offices and the council room. Nearby, two buildings provide initial accommodation for the science departments, one housing the Departments of Botany and Zoology, the botanical garden and the vivarium being immediately adjacent, while another will provide permanent housing for the Departments of Chemistry and Physics. The third will be that accommodating the agricultural laboratories.

The first portions of three halls of residence have already been built, grouped around a park in the residential area of the site. All three are designed on the same pattern and when complete will accommodate 120 students each. To each will be attached a warden's house, dining hall, kitchen and common room. Individual study–bedrooms are arranged in corridors of eight, each of which ends in a sitting room and balcony. At the time of the installation ceremony, the dining room in only one of the halls was in operation, and in this all the undergraduates were taking their meals together. The design of the buildings so far erected is modern without stridency. Functional forms have been softened in a manner which allows them to sink effectively into the background in which they are built.

In the north-west corner of the site lies a large quarry which, by a happy inspiration, has been converted into an open-air amphitheatre, seating more than three thousand people, for ceremonies,

concerts and theatrical performances, and it was here that the installation of the Queen Mother took place. Those who were responsible for the planning of this are to be congratulated.

Of the seventy full-time students at the College in July 1957, fourteen are members of the Faculty of Science, taking the B.Sc. (General) course in science of the University of London. Fifty-four of the students are resident; eight, including one woman, are African and there is one Indian woman student who is non-resident. Of the subjects coming under the Faculty of Science, chemistry is the most frequently studied, having about twice as many students as other subjects. Botany, mathematics, physics and zoology enrol approximately the same numbers.

Of the nine professors who have at present taken up their appointments, five are in the Faculty of Science, three are in the Faculty of Arts (African studies, English and education), while a special appointment as director of the Institute of Education is held by Prof. B. A. Fletcher. The library, which already contains nearly 16,000 volumes, is regularly receiving 450 journals.

As has been said more than once, in a country where racial tension can arise, the position of a multi-racial university is especially important. The declared aim of the Central African Federation is a partnership between the races, European and non-European, and to the attainment of this ideal the University College of Rhodesia and Nyasaland, with the goodwill of the people and Government support, will make a most important contribution. In the words of the motto of the University College, 'Wisdom builds the house of life'. Wisdom has indeed gone to the founding and fostering of this new University institution, and to the principal, Dr. Walter Adams, and to all his staff, universities all over the world will look for the results of a most important educational experiment during the coming years.

F. G. Young

OBITUARIES

Dr. Harold Thompson

Only a few of the ex-Servicemen who entered fishery research in 1920 had survived as soldiers from the beginning of the war-period 1914–18, and among them was Capt. Harold Thompson, of the Royal Field Artillery, who had served five years in France and had twice been mentioned in dispatches. His first fishery research was on the great number of haddock scales collected by the Scottish research vessels. They made very good sense when handled by Thompson, who was soon able to forecast with some accuracy the fortunes of the important North Sea haddock fishery. The basis was the relative abundance of annual broods of fish, as shown by catches of ages below those at which they exerted their full commercial weight. Thompson's success convinced us all that the Norwegian methods need not be confined to their own fisheries, where extreme annual fluctuations were the rule, and forecasting became, after Thompson's work, one of the standard aims of fishery research everywhere.

Harold Thompson was born on October 12, 1890. He was the son of William Thompson, who was headmaster of the Middle School, Aberdeen. After graduating in arts in 1912, he taught for one year in Perthshire and returned to the University of Aberdeen with the intention of taking a science degree. On the outbreak of war, however, he enlisted in the Gordon Highlanders and was later promoted to commissioned rank in the artillery.

In 1920 Thompson obtained special distinction in chemistry and zoology for his B.Sc. degree at Aberdeen and, after a short period assisting in the Biochemistry Department in the University of Edinburgh, was appointed a junior naturalist by the Fishery Board of Scotland in 1921. His doctorate was awarded for a thesis on the local growth-rates, age analyses and migrations of the haddock. He did not, however, relinquish his interest in systematic zoology. Although he was to carry for most of his working life the responsibility of a director, he yet found time to make substantial additions to knowledge of the tunicates.

For some years the Government of Newfoundland, then proudly calling itself Britain's oldest Dominion, had been anxious to know more about the fish on which the economy of the island mainly depended. In 1930 Thompson undertook a survey of the fisheries, and in 1931 he was made the first director of fisheries research in Newfoundland. He built up an organization based on Bay Bulls near St. John's and used a trawler for research purposes, making not only the usual ecological surveys but also attempting some codification of the undoubted relationship between cod catches and temperature, which had been explored first by Commandant Beaugé of the French Fisheries Service. Thompson gave, with due reservations, something of a guide to favourable temperatures in different regions and for different sizes of cod, and this provided a basis for more recent work in other parts of the world where there is mixing of Arctic and Atlantic water. Sometimes the relationship is as it were accidental, depending really on the movement of the water-masses; sometimes it is vital, and I think that Thompson fully realized both possibilities.

In 1937 Thompson was again to found a new fisheries laboratory, this time at Cronulla, near Sydney, with subsidiary stations in other parts of Australia. He attracted and selected staffs of high quality, and a substantial bulk of excellent work has come from his foundations. He retired from the post of chief of fishery investigations in December 1954, and the library at Cronulla is named after him.

In appearance, Thompson was spare, dark and keen looking. He looked what he was—penetrating, critical and reliable. He could not have achieved what he did without a firm intention amounting almost to enthusiasm; but he also gave full measure of scepticism where it was required, and accepted without apparent concern the resulting ingratitude. He engendered the firm respect and affection of those who appreciated his highly tempered quality. Thompson died in Edinburgh on May 29, and leaves a widow and son who will have all our sympathy.

Michael Graham

Mrs. Alice Sophia Cooke

Mrs. Alice Sophia Cooke (Mrs. A. S. Bacon), head of the Biology Department of Brighton Technical College during 1920–30, died at her home in Hassocks, Sussex, on May 21. Mrs. Cooke was born in London in 1890. In 1909 she obtained a Drapers' Company scholarship from the City of London School for Girls to the East London College (now Queen Mary College). There, as one of the late Prof. F. E. Fritsch's first students, she took her B.Sc. honours degree in botany in 1912, and was then appointed assistant biology mistress at the Swindon and North Wiltshire Secondary School and Technical Institute. In the following year she went to Huddersfield Technical College as assistant lecturer in biology, and in 1920 was appointed lecturer in biology at Brighton Technical College. Until her arrival at Brighton no systematic teaching in biology was undertaken there, but within five years a number of her students had obtained University of London honours degrees in botany, and the courses for the intermediate, first M.B. and matriculation examination were all well established.

She will be remembered as an inspiring and dedicated teacher who might have achieved great distinction in research. Instead she spared no pains in providing her students with a balanced training in botany in which each branch was introduced with an equally infectious enthusiasm. To her students her standards appeared appallingly high, but they were invariably achieved by a careful blend of admonition and encouragement. Outside the university examination courses she took a great deal of practical interest in her evening classes in horticultural botany for gardeners, and she was also well known for her activities in the educational field, more especially in the teaching of science.

As a field botanist Mrs. Cooke had an unrivalled knowledge of the Sussex flora and had travelled widely both in the British Isles and on the Continent, in the course of which she built up a remarkable collection of botanical material including an extensive bryophyte herbarium, all of which was constantly used in her lecture courses.

She was elected a Fellow of the Linnean Society of London in 1922 and also belonged to the British Bryological Society, the British Ecological Society, the British Mycological Society, the Brighton and Hove Natural History Society and the Freshwater Biological Association.

Mrs. Cooke had great personal charm; she would generously give her time to others, and she followed the subsequent careers of her students with interest. Her influence on botany has been indirect, through her students, and the many botanists, zoologists, pharmacists and others whom she trained have derived immeasurable benefit from the teaching of one of the most able of botanical teachers.

P. K. C. Austwick

NEWS and VIEWS

Manchester Museum: Mr. R. U. Sayce

Mr. R. U. Sayce, who is shortly retiring from the keepership of the Manchester Museum in the University of Manchester, was appointed to that post in 1935, and since that year has done much to modernize the display. He has had the task of keeping the balance between the two major responsibilities of the Museum, namely, those of making the collections attractive to the public, while at the same time maintaining their value to students from the University. Throughout this period Mr. Sayce has also maintained close co-operation with local learned societies, undertaken much research, published the results of his work, and acted as honorary editor to the *Montgomeryshire Collections* for more than twenty-five years. Throughout he has organized an invigorating schools service, thus bringing an atmosphere of freshness and vitality to the Museum. In 1941 he was president of the north-western Federation of Museums and Art Galleries and in the national sphere was president of Section H at the Brighton meeting of the British Association in 1948. Mr. Sayce has served museums and scholarship with distinction, and in his retirement intends to continue his work in both these interests.

Dr. D. E. Owen

Dr. David E. Owen, who is to succeed Mr. Sayce as keeper of the Manchester Museum, is by training a geologist who has specialized in the administration of museums. Appointed curator in geology at the Public Museum, Liverpool, in 1935, he became director of the City Museum, Leeds, in 1947 and has now completed ten years in that city. While at Leeds he has planned and built a model coal mine, planned two streets of craft workshops at the Abbey House Museum and has recently been responsible for the layout of an instructive Geological Garden. He has always been interested in the relationship of the Museum with the public and has done much to bring museums to the attention of the ordinary individual. In the wider sphere, he has given much voluntary service to the aims and objects of the Museums Association and is now its honorary treasurer. Dr. Owen will thus bring to Manchester a wealth of experience in modern display, a deep conviction of the value of museums and an academic approach which is so essential in a university museum.

Radiation Research Visiting Club

A Radiation Research Visiting Club was formed in 1953 in response to a desire among radiobiologists in Britain to meet one another and to visit each others laboratories. An invitation list was compiled of institutes and laboratories where work is in progress in the field of radiation biology, radiation medicine, radiation physics and radiation chemistry, and to this list was added the names of a number of individuals known to be working in this field but unattached to any of the enrolled laboratories. Four meetings of the Club have been held, and each has been organized entirely by the host institute. At the present time the Club is very informal in nature,

there being no elected officers, and the only record kept being the roll of attendance at each meeting.

The number of workers in the field is steadily increasing and a time must come when some host institutes will find it impracticable to invite everyone on the roll to the meetings which they are organizing; but this is regarded as an additional reason for making the existence of the Club as widely known as possible. Intending host institutes would like to inform all interested workers of a particular forthcoming meeting and invite as many as possible of those who indicate a desire to attend. If, therefore, there are workers who do not already receive notices of the meetings of the Radiation Research Visiting Club, either as individuals or through a group with which they are working, but would like to receive such notices, they should inform Dr. L. F. Lamerton at the Physics Department (Downs Branch), Royal Marsden Hospital, Clifton Avenue, Belmont, nr. Sutton, Surrey, where the next meeting of the Club will be held in November.

Animal Health Trust Educational Awards

The Animal Health Trust awards for the period 1957–58 include the following: *Wellcome Fellowships:* L. F. Taffs (Downing College, Cambridge), to study immune reactions of pigs to worm parasities, particularly *Ascaris lumbricoides*, under Prof. W. I. B. Beveridge at the Department of Animal Pathology, School of Veterinary Medicine, Cambridge; J. S. M. Hutchinson (Nottingham University School of Agriculture), to carry out a quantitative evaluation of changes in gonadotrophin levels in the pituitary gland of the ewe in reproductive states by means of a biological assay in conjunction with cytological studies, under Dr. H. A. Robertson, at the Biochemistry Section, Department of Agricultural Science, University of Nottingham; P. J. McCosker (University Veterinary School, Brisbane, Australia), to study aspects of copper metabolism in bovine blood at the Department of Clinical Studies, Cambridge, under Prof. L. P. Pugh. *Research Training Scholarships:* F. A. Harrison (University of Liverpool), to take an honours course in physiology in the Department of Physiology, University of Liverpool, under Prof. R. A. Gregory; D. F. Kelly (University of Bristol), for further studies in the Department of Pathology, Cambridge, under Prof. H. R. Dean; D. B. Ross (Trinity College, Cambridge), to study the mineral metabolism of sheep with particular reference to mechanisms responsible for homœostasis, at the Department of Animal Pathology, Cambridge, under Prof. Beveridge.

Physics of Elementary Particles

A symposium on the physics of elementary particles was held during July 15–30 at Buenos Aires and La Plata, Argentina. The symposium was sponsored by Unesco, the Argentine Atomic Energy Commission and the Universities of Buenos Aires and La Plata, and was attended by physicists from Argentina, Brazil, Chile, Bolivia, Uruguay and other South American countries. Dr. B. Cork was invited from Berkeley, California, and Prof. Abdus Salam from the United Kingdom. An attempt was made to survey the entire theoretical and experimental development of elementary particle physics. There were, in addition, a number of original communications from various delegates. The success of the symposium was due to the hospitality of the Argentine Atomic Energy Commission and the efforts of the organizing committee, which consisted of Profs. E. D. Galloni, J. J. Giambiagi, J. G. Roederer, and J. F. Westerkamp.

Conference on the Mechanical Properties of Non-Metallic Brittle Materials

For some years the National Coal Board's Mining Research Establishment at Isleworth, Middlesex, has been studying the properties of coal with the view that greater understanding of the material will aid the development of improved techniques for mining and handling it. Parallel work is being started on coal measure rocks in relation to methods of breaking them down, and of controlling the strata around mining excavations. The work includes development of test methods whereby these materials can be classified and described in a way which will guide the mining engineer in his choice of methods of working, and also laboratory studies of breakage under various patterns of applied stress with the object of developing improved mining techniques. A particular difficulty in this work, as in that on other brittle materials, lies in the variability of behaviour necessitating a statistical approach. It is felt that many of the problems are common to research in other substances, road and building materials, for example, or glass and ceramics. It is therefore planned to hold a Conference on the mechanical properties of non-metallic brittle materials at the Mining Research Establishment on April 1 and 2, 1958, with papers by National Coal Board staff and invited contributions from other organizations. The programme, arranged in consultation with the Building Research Station of the Department of Scientific and Industrial Research, includes strength in compression, tension, bending and shear; elastic properties and liability to creep; dynamic and repeated loading including shock waves, crack propagation and the effects of impact; the action of tools including wedge penetration normal and parallel to the surface, friction and abrasion. It is intended to circulate papers in advance and to introduce them very briefly at the Conference so that a maximum proportion of the time can be spent in discussion.

Zoological Nomenclature

The International Commission on Zoological Nomenclature gives notice that, as from February 26, 1958, it will start voting on the following cases involving the possible use of its plenary powers for the purposes specified against each entry. Full details of these cases were published on August 26 in the *Bulletin of Zoological Nomenclature* (12, Part 12, and 13, Part 8): (1) *parvula* Mörch, 1863 (*Aplysia*), validation (Cl. Gastropoda); (2) *Anodonta* Lamarck, 1799, validation (Cl. Pelecypoda); (3) *padi* Linnæus, 1758 (*Aphis*), validation (Cl. Insecta, Order Hemiptera); (4) and (5) *lineata* Young and Bird, 1828 (*Terebratula*), and *subconcinna* Davidson, 1852 (*Rhynchonella*), interpretation (Cl. Brachiopoda); (6) *anonyma* Lewis, 1872 (*Liminitis*), suppression (Cl. Insecta, Order Lepidoptera); (7) *obtusa* Montagu, 1803 (*Bulla*), validation (Cl. Gastropoda). A proposal is also made for the adoption of a declaration clarifying the status of adjectival specific names consisting of partly Latinized words. Comments should be sent as soon as possible in duplicate to Francis Hemming, Secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

Oversea Service Division, Colonial Office

THE following appointments have recently been made in the Oversea Service Division, Colonial Office: E. C. Clarke (assistant conservator of forests, class 2, Cyprus), assistant conservator of forests, class 1, Cyprus; D. Moore (deputy conservator of forests, Trinidad), conservator of forests, Trinidad; J. C. Mouskos (administrative officer, class 2, Cyprus), assistant conservator of forests, class 1, Cyprus; D. Jones (meteorologist, grade 1, Federation of Nigeria), senior meteorologist, Federation of Nigeria; R. H. Williams (deputy chief surveyor, Federation of Malaya), chief surveyor, grade 2, Federation of Malaya; W. N. Scott (assistant director of Veterinary Services, Uganda), deputy director, East African Trypanosomiasis Research Organization, East Africa High Commission; E. K. Clarke, agricultural officer, Nyasaland; D. M. Hill, agricultural officer, Nyasaland; J. P. Law, agricultural officer, Sierra Leone; N. Le Poidevin, agricultural officer, Gambia; D. McDonald, plant pathologist, Northern Region, Nigeria; C. K. H. Martini, plant pathologist, West African Cacao Research Institute, Western Region, Nigeria; T. G. Moffatt, agricultural officer, Northern Region, Nigeria; R. Orpin, agricultural officer, Nyasaland; D. J. H. Thomas, agricultural officer, Western Region, Nigeria; J. M. S. Burgess, assistant conservator of forests, Nyasaland; E. W. Gregor, assistant conservator of forests, Somaliland Protectorate; D. B. Webb, assistant conservator of forests, British Honduras; J. F. Bateson, geologist, Seychelles; W. E. Evans, geologist, Cyprus; T. A. Moore, geologist, Cyprus; R. D. Morris, geologist, Cyprus; A. F. Fraser, veterinary officer, Jamaica; G. D. Harris, veterinary officer, Northern Region, Nigeria.

The appointment of J. H. Hill was as geologist, British Solomon Islands Protectorate (and not Fiji, as printed in *Nature* of June 15, p. 1225).

The Night Sky in September

FULL moon occurs on September 9d. 04h. 55m. U.T., and new moon on September 23d. 19h. 18m. The following conjunctions with the Moon take place: September 1d. 04h., Saturn 0·6° S.; September 26d. 18h., Venus 2° S.; September 28d. 14h., Saturn 1° S. In addition to these conjunctions with the Moon, Saturn is in conjunction with Antares on September 6d. 06h., Saturn being 6·2° N., and Venus with Spica on September 7d. 22h., Venus being 2·1° N. Mercury will be visible as a morning star during the last week of September, rising at 4h. 30m. on September 30. Venus sets about an hour after the Sun, and will be visible as a bright object low in the west just after sunset. Mars and Jupiter are too close to the Sun for observation. Saturn sets at 21h. 55m., 21h. 00m., and 20h. 05m. on September 1, 15 and 30, respectively; it is moving eastwards in Ophiuchus, being north of Antares. Saturn has stellar magnitude + 0·8 and a distance on September 15 of 950 million miles. There is one occultation of a star brighter than magnitude 6, observation being made at Greenwich: September 21d. 3h. 48·8m., ω Leo. m. (*R*). *R* refers to reappearance. There is a daylight occultation of Saturn on September 28, visible at Greenwich. Disappearance is at 12h. 47·7m., reappearance at 13h. 44·9m. The autumnal equinox occurs on September 23d. 07h.

Announcements

DR. MARTIN H. MOYNIHAN, who graduated at Princeton and carried out postgraduate studies at Oxford, has been appointed resident naturalist of the Smithsonian Institution's Panama Canal Zone Biological Area, a tropical forest and wild-life preserve on Barro Colorado Island in Gatun Lake, Canal Zone.

MR. R. D. JOHNSTON has been awarded a fellowship for postgraduate research in the Department of Metallurgy at Battersea College of Technology, London, by the British Oxygen Co., Ltd.

APPLICATIONS for grants from the Research Fund of the Chemical Society for the assistance of research in all branches of chemistry should be submitted on the appropriate form by November 14. Forms of application together with the regulations governing the award of grants can be obtained from the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1.

THE Institute of Welding has established a School of Welding Technology at its house at 54 Princes Gate, London, S.W.7, and courses on various aspects of welding, each lasting a week, will be arranged during October–March. Particulars can be obtained from the Secretary of the Institute.

THE scientific activities of Morley College, London, are being increased in connexion with the rebuilding of the College, which was damaged during the Second World War. Still further facilities will be available when the new building opens early in 1958. The programme of courses on science, which include lectures on various aspects of natural history, gardening, public health, agriculture, photography, microscopy, astronomy and statistics, can be obtained from the Director of Science, Morley College, 61 Westminster Bridge Road, London, S.E.1.

THE British Scientific Instrument Research Association has extended its forthcoming series of open days, originally to be held during the week October 7–11, to include October 14. Admission is by invitation only, and inquiries should be addressed to the Director, British Scientific Instrument Research Association, Southill, Elmstead Woods, Chislehurst, Kent.

THE National Conference of the Institute of Personnel Management will be held in Harrogate during October 4–6. Further details may be obtained from the Secretary to the Institute at Management House, 80 Fetter Lane, London, E.C.4.

THE sixth Anglo-American Aeronautical Conference, under the joint auspices of the Royal Aeronautical Society and the U.S. Institute of the Aeronautical Sciences, is to be held at Folkestone during September 9–12. The Conference is open only to members of the sponsoring organizations.

THE Scottish Group of the Nutrition Society is holding a symposium on "The Nutrition of the Very Young" in Dundee on September 21. The papers to be read will deal with both infants and young farm animals. Further particulars can be obtained from Dr. J. Davidson, Rowett Research Institute, Bucksburn, Aberdeenshire.

ELECTRICAL ENGINEERING AT THE UNIVERSITY OF SHEFFIELD

NEW LABORATORIES

THE new laboratories of the Department of Electrical Engineering in the University of Sheffield were officially opened by Sir Harold Bishop (director of engineering, B.B.C.) on June 28. Speaking at the ceremony, Sir Harold referred to the problems facing the universities in their efforts to meet the growing needs of industry. "Whatever may be the answer to these problems," Sir Harold said, "the rate of expansion in the electrical industry (and I would remind you that the value of the exports of that industry are now greater than that of any other industry in this country) is clearly limited by the rate at which the supply of trained scientists and technologists can be increased." The new laboratories will, it is hoped, make a useful contribution by providing facilities for a substantial increase in the number of students of electrical engineering in the University of Sheffield.

The laboratories are accommodated in the applied science buildings facing St. George's Square. In addition to space previously occupied by the Electrical Engineering Department in these buildings, further space became available by the transfer of the Department of Civil Engineering, and most of the Department of Mechanical Engineering, into a new engineering building which was opened in 1955. In this way the floor area of the laboratories has been almost doubled, and the original laboratories, as well as the new laboratories, have been completely refurnished and re-equipped.

Four of the laboratories are used for heavy-current work, three mainly for machines, and the other for transformers, rectifiers and other static apparatus. One of the machines laboratories is the Edgar Allen Laboratory and is devoted to research in electrical machinery and related topics. A very comprehensive range of machines and other apparatus is available. A mono-rail and a small mobile gantry provide for the movement of heavy equipment. However, many of the smaller machine-sets are mounted on wheels, which gives great flexibility in use.

There are two large laboratories used mainly for undergraduate experiments in measurements, electric circuits and electronics. A small photometric laboratory with photometric bench, integrating-cube and other illumination test apparatus is available. In the standards laboratory a complete inner room has been built of aluminium-faced plywood to form a complete metal screen, with properly filtered incoming supplies. This is used for precision measurements, and is equipped with d.c. and a.c. potentiometers, bridges, and standards of resistance, inductance and capacitance.

The electronics laboratory and the microwave laboratory are used entirely for research. The former contains high-vacuum equipment generously given to the Department by the Metropolitan-Vickers Electrical Co., Ltd., while the latter is equipped with oscillators, wave-guide test-benches and other apparatus for experimental work in the microwave and decimetric frequency bands.

The Department also has two workshops, one of which is used by postgraduate students, and a battery-room housing a 200-V., 900 amp.-hr. centre-tapped lead–acid battery which supplies the 3-wire d.c. system throughout the Department. The charging equipment consists of a motor generator, a booster-balancer set and metal-rectifiers.

The electric power supplies in the laboratories have been designed to give the greatest possible flexibility consistent with reliability and safety. The light-current laboratories are generously provided with 3-pin, 13-amp. switch-sockets for both 240 V. single-phase a.c. and with 5-amp. and 15-amp. switch sockets for 200 V. d.c. These supplies meet most needs in these rooms, but each laboratory is also equipped with at least one four-wire, 30-amp. experimental terminal board, fed from a socket on the main switchgear cubicle in the large machines laboratory. This provides for interconnexion between laboratories and for special supplies if required. The 240-V. a.c. supply for these laboratories is taken from a 415-V., 3-phase and neutral, ring-main which has been installed for the general supply to the whole building. The direct current is supplied from the battery already mentioned.

In the four heavy-current laboratories a rather special system of distribution is used. The normal supplies available in these laboratories are: 415 V., 3-phase and neutral; 230 V., 3-phase and neutral; and 200 V., 3-wire d.c. (100/0/100), from the battery. With the exception of the Edgar Allen Research Laboratory, which has separate 415-V. and d.c. supplies, the main control for all the supplies to these laboratories is by isolaters and splitters located within the main cubicle in the large machines laboratory. Adjacent to this is the 415/230 V., 3-phase, 100-kVA. autotransformer, which also has 110-V. tappings taken to a socket on the cubicle.

The three supplies are not fed direct to the machines, except to a few of the largest, but are connected to a special cubicle in each laboratory. Each incoming supply to these is controlled by a fuse-switch, feeding a number of 4-pole sockets all separately fused. Four-core flexibles are used, with a shielded plug on each end, to connect these sockets to others which are connected to outlet or experimental points distributed around the laboratory. In addition, each cubicle has two sockets connected to corresponding sockets on the main cubicle in the large machines laboratory, where any inter-laboratory connexion can be made.

At the experimental terminal boards the four cables terminate in switch-fuses connected to insulated terminals (four colours). The terminal boards have doors with locks for access to fuses, and each is provided with an independent 13-amp. switch-socket for 240-V. a.c. supplies to oscilloscopes, portable lamps and other test apparatus. The connexions have been made systematically, so that not only is the phase-sequence correct at every set of terminals, but also the red terminal is always connected to the 'red' line, and when interconnexion is made between experimental points, the two sets of terminals are connected in the proper order. The cubicle in the large machines laboratory serves its own system

within that laboratory as well as acting as the focal point to which all the others are connected. It has 60-amp. plugs and sockets, and so has the Edgar Allen Research Laboratory. The others have 30-amp. circuits. Wherever possible, the wiring is carried in surface trunking and is easy of access.

With the exception of the photometry and standards laboratories, which have tungsten filament lighting, the laboratories are very adequately lit by fluorescent lamps. These are switched in groups of three or six, fed from 3-phase a.c., with 3-pole switches, so eliminating stroboscopic effects and reducing the number of wall switches.

The University surveyor was responsible for the design and supervision of the alterations and additions, the electrical consultants being Hoare, Lea and Partners. The main buildings and fittings contractors were Geo. Longden and Son, Ltd., and the electrical contractors were the Yorkshire Electricity Board. The special experimental panels and cubicles were designed and manufactured by Field and Grant, Ltd. (Birmingham).

INTERNATIONAL TIN RESEARCH COUNCIL

TWENTY-FIFTH ANNIVERSARY

By Dr. ERNEST S. HEDGES
Director

TO celebrate its twenty-fifth anniversary the International Tin Research Council invited visitors to the open days held at the Tin Research Institute, Greenford, Middlesex, on July 10 and 11. The Institute was built in 1938 to house the Council's headquarters and research laboratories, but after the War extensions were necessary and new laboratories were opened by H.R.H. the Duke of Gloucester in 1951. This had the effect of doubling the accommodation. The staff of the Institute comprises about twenty graduates and forty-five assistants, including maintenance and services. The present director has served the Council during the twenty-five years of its existence.

During the open days approximately six hundred people visited the Institute, among them many well-known scientists, technologists and industrialists. The full tour of the laboratories was designed to show the main developments which have resulted from the Institute's research work. The general scheme followed wherever practicable throughout the laboratories was to show the actual experimental equipment employed on investigations, pilot or full-scale plant for operating the technique developed from it, and commercially produced samples illustrating the final product.

An example of this treatment was to be seen in the Electroplating Department. Work having as its aim the production of electrodeposits of new tin alloys was initiated on a beaker scale in the first laboratory, developed on a 10-gallon scale in the second laboratory and brought to practical success on a 200-gallon scale in the third. Among the practical achievements of the Institute presented in this way was a considerable range of metallic coatings containing tin. The decorative and corrosion-resistant electroplate of tin–nickel alloy (66 per cent tin) was shown as a finish on an electric toaster, a table lamp, drawing instruments, spoons, chemical balance weights, slides of trombones and pistons of trumpets. Speculum (a tin–copper alloy containing 42 per cent tin) was seen upon a lamp, a fruit bowl and a reflector. Tin–zinc alloy (75 per cent tin) was shown on undercarriage parts of aircraft, radio chassis and motor-car accessories. This alloy coating has gained wide acceptance as a corrosion-resistant finish for steel. A recent development in this department which attracted much attention was the electrodeposition of 'bright' tin. This is a process for producing, without mechanical polishing, a pure tin coating having a mirror-like reflexion. Bright tin was demonstrated on a radio chassis stamped from unpolished steel sheet.

In a suite of laboratories specially designed for hot-tinning, the hot-dip tinning of steel and cast iron was demonstrated on such objects as frying pans. After tinning, these were immediately centrifuged in equipment designed at the Institute to remove excess of the still molten tin, leaving a bright and flawless surface. Tinned cast-iron meat-mincers showed the great improvement in surface brightness and smoothness brought about by the use of new techniques worked out in this laboratory. Adjoining laboratories displayed equipment designed for the study of electrolytic tinplate produced under controlled conditions, including 'flow-brightening' by momentarily melting the surface. The many testing procedures which have emanated from this laboratory for assessing tin coatings quantitatively and qualitatively were also demonstrated.

The Metallurgical Department showed stages in the roller-welding of steel strip to aluminium–tin alloy strip so as to form composite strip, from which half cylindrical bearing shells for high-duty internal combustion engines can be formed by pressing and subsequent machining. This new type of bearing, which is now in commercial production, is already being used in tens of thousands of road vehicles. The continuous casting of bronze rod was a demonstration of much interest. The rod, produced at about 12 in. a minute, is remarkable for its high quality and accuracy to gauge diameter. The machine, which was expressly designed at the Institute to be of simple and inexpensive construction, has been adopted by many firms in Europe.

The Corrosion Department had exhibits to illustrate the advantages of each type of tin and tin–alloy coating under specific conditions of usage. The remarkable permanence of tin–nickel coatings under severe conditions, such as industrial atmospheres, impressed many visitors. The structure of surface films on tin and tin alloys is also a subject of study in this laboratory, using techniques by which the films are removed intact from the metal on which they form: several specimens of such films were on show.

Organo–tin compounds are among the most recent studies of the Institute and perhaps the one for which the brightest future seems to be in store. Certain of these compounds, containing a tin atom linked to three carbon atoms, are remarkably toxic to fungi. A practical demonstration was afforded by two timbers recently removed from a damp mine where they had been for more than three years: the untreated timber was crumbling away while the timber treated with a trialkyl–tin compound was unaffected

and retained its full strength. Other exhibits showed the effectiveness of these compounds on timbers exposed to attack by *Teredo* and other marine organisms. Another type of organo–tin compound has exceptional ability to stabilize polyvinyl chloride plastics. Curiously, the same type of compound is used extensively in veterinary medicine as a worm cure and prophylactic for chickens and turkeys. The chemistry of organo–tin compounds is being rapidly extended by the Institute's research team.

Other departments shown included metallography, analytical chemistry, photographic studios, engineering workshop and a specialized library. Cinematograph films of processes devised in the laboratories were available for continuous showing to the visitors.

FULMER RESEARCH INSTITUTE

OPEN DAY

THE Fulmer Research Institute held an open day on July 2, to mark the tenth anniversary of the official opening by Sir Stafford Cripps on July 2, 1947. About 260 guests, representing industry, government departments and other research organizations, were present and were shown details of research work in progress.

The principal guest was Mr. R. Harmar Nicholls (Parliamentary Under-Secretary, Ministry of Works), who deputized for the Right Hon. Reginald Maudling. In a brief speech after lunch, Mr. Nicholls congratulated the Institute on its steady growth during the past ten years, and, in reflecting on the sources of the Institute's income, Mr. Nicholls was particularly gratified by the increasing number of dollar-earning research contracts, now constituting about one-third of the Institute's total income. He considered, however, that much greater use could be made by British industry of the facilities for research and development which are available at the Institute.

During the past ten years the Institute's effort has been principally devoted to some one hundred and fifteen major research programmes, and about thirty of these are in progress at the present time.

In the physical chemistry division of the Institute, headed by Dr. P. Gross, fundamental work on extraction processes relating to aluminium and titanium has continued. Pilot-plant work in industry on the catalytic distillation of aluminium has been in progress for some time and processes for titanium extraction which have been successfully demonstrated on the laboratory scale are now ready for extension to the next stage. A method of purification of silicon is now under experimental study and apparatus for the preparation of large single crystals of this element (by drawing from the melt) has been developed and is in use.

The work on extraction and purification processes is, of course, dependent upon accurate thermodynamic data, and specialized techniques have been used to study the equilibria of important industrial reactions and to establish activity data for various metallic systems. Accurate calorimetry has established the heats of formation of various compounds, in particular metallic halides, and new values for several of these important compounds have been published. Various reactions which might form the basis of new extractive methods have been studied in apparatus requiring highly efficient vacuum techniques. In the analytical laboratories, polarographic, absorptiometric, microchemical and spectrographic methods in addition to the more conventional techniques of analysis were demonstrated.

A study of the mechanism of precipitation hardening with particular reference to light alloys has always been a major item in the Institute's research programme. It was partly as a result of this work, much of which has been published, that Dr. H. K. Hardy, who has since joined the Atomic Energy Authority, gained the Beilby Award and Rosenhain Medal of the Institute of Metals. The X-ray techniques developed by the Institute's investigators for studying precipitation processes are well known internationally to specialists in the field. Trace elements have been shown to exercise a profound effect on ageing behaviour in some systems, and the influence of small quantities of cadmium, for example, on aluminium–copper alloys has resulted in the development of a series of alloys which, while free from room-temperature ageing after solution treatment, can be aged at elevated temperatures to yield properties approaching those of the duralumin type alloys. The effect of radiation on precipitation and ageing behaviour in aluminium alloys is now being studied, while in titanium and zirconium alloys attention is being paid to the crystallographic changes associated with the formation of the embrittling omega-phase. To assist this latter work and more particularly for studies on transformations in alloys of reactive metals, a special X-ray camera has been developed. It can operate with the specimen at temperatures up to 1,000° C. in a vacuum of 1×10^{-7} mm. of mercury.

Other X-ray studies have been concerned with the structure of liquid metals, and interesting results have been obtained with sodium and potassium (including binary alloys of these metals) and also gallium. The fundamental structure of glass is also being examined. Although in glasses the atoms are not arranged in a regular crystalline manner characteristic of metals, the arrangement is not completely random. On the slight degree of regularity which does obtain, an explanation of the variation of the properties of glass with heat treatment is sought. The problem is closely linked with that of liquid metals, and somewhat similar techniques of X-ray diffraction and refined interpretation are being applied.

A recent addition to the equipment of the physics section is the Metropolitan-Vickers electron microscope type *EM3A*. This instrument, which has a resolution of 20 A. under favourable conditions and which can also be readily adapted for electron diffraction, is being used principally to study the mechanism of oxidation of low-alloy steels and to supplement the X-ray and metallographic investigations on age-hardening phenomena. A detailed investigation of the slip characteristics of certain metals is also in progress.

New equipment on view in the physical metallurgy section included a Reichert metallurgical microscope, a precision dilatometer for use in isothermal transformation studies and a high-temperature (up to 2,000° C.) vacuum heat treatment furnace. The last two items, together with much of the other equipment in use, were constructed in the laboratory workshops.

While considerable attention is still being paid to aluminium alloys, developments in the atomic energy

field in particular have been reflected in the increased amount of work on the 'newer' metals, and uranium, titanium, zirconium, hafnium, niobium and vanadium all figure prominently in the current work of the Institute. A number of research programmes are concerned with the physical metallurgy of uranium and its alloys, and they include the determination of constitutional diagrams for certain binary alloys, the study of phase transformations, and determination of the crystal structure of uranium compounds. A metallographic study of the allotropic transformation in binary titanium zirconium alloys has recently been concluded.

In the work on materials for possible application at high temperatures, comprehensive investigations on binary and ternary chromium-based alloys have been followed more recently by an examination of the pure metal. Experimental and pilot-plant work on electrolytic processes has been concerned with identifying and controlling commonly occurring impurities and this has been coupled with an examination of the effects of these impurities on mechanical properties. Results of impact tests obtained on material which has been obtained by the lubricated extrusion of sheathed compacts have shown that this extrusion method has an effect of increasing the ductility and lowering the ductile/brittle transition temperature in chromium. A new retractable hearth argon-arc melting furnace for the production of chromium and chromium alloy ingots has recently been built.

Further attention has been paid to the low-alloy oxidation-resistant steels. A recently published report (Fulmer Research Institute: Special Report No. 2. "Oxidation Resistant Silicon–Aluminium Steels") describes fully the properties of these low-carbon steels containing silicon and aluminium developed at the Institute, which in air at temperatures up to about 950° C. exhibit a degree of scaling resistance comparable with the well-known austenitic stainless steels. Other work in the field of ferrous metallurgy has included an examination of the causes of failure of high-speed steels with special attention to the susceptibility of this complex material to overheating. Some short-term programmes have been concerned with nodular cast iron.

Long-term corrosion and stress corrosion tests are in progress on the various aluminium alloys, and particular attention has been paid to the effect of directionality of metallurgical structure on the initiation and rate of corrosion attack. Fundamental aspects of stress corrosion cracking and layer corrosion are under investigation and more recently a research programme to determine the effect of various metal coatings on the fatigue and corrosion fatigue properties of high-strength aluminium alloys has begun. The development of corrosion-resistant aluminium-base structural alloys, the development of oxidation and shock-resistant coatings for high-temperature materials, the assessment of a new material for domestic hot-water boilers, and an examination of coatings for the protection of high-strength aluminium alloys are other subjects under active investigation. The high-temperature corrosion of zirconium, a matter of importance for the application of that metal in nuclear reactors, is also the subject of a major research programme.

The primary interests of the engineering and mechanical testing laboratories lie in the fields of creep and fatigue. Fundamental programmes are concerned, for example, with assessing the importance of rest periods and cumulative damage on fatigue life. A specially designed high-temperature fatigue machine has proved particularly useful in studying the effect of various heat-resisting coatings on the high-temperature fatigue properties of the basis metal. High temperature and corrosion fatigue studies are also being made using alternating tension and compression machines of the Haigh or 'slipping clutch' type.

Apart from the more usual tensile creep testing, small compression creep machines have proved particularly useful for the study of uranium and other highly reactive metals. A comprehensive investigation of the creep characteristics of certain binary alloy systems is also in progress to ascertain the effect on creep properties associated with changes in the solid state occurring at or near phase boundaries. Titanium alloys, aluminium alloys, magnesium alloys (for 'canning' uranium fuel elements), structural steels and cast iron are other materials on which creep-testing programmes have been carried out.

Facilities for mechanical testing have been adapted so that tests can be carried out at very low or high temperatures. Results have been obtained, for example, for sponsors interested in designing for low-temperature applications, such as the transport of liquid methane. The mechanical and thermal properties of various insulating materials have also been examined and another investigation has been concerned with the determination of the characteristics of oil filters by measurement of the pressure drop at various flow-rates of fluids of varying viscosities.

While much of the Institute's work remains confidential to the sponsors, more than one hundred papers and technical articles (in addition to a number of patents) have been published with the sponsors' permission. Reprints of most of these were available in the Institute's library, together with a large number of translations of foreign scientific papers, including many translated from the original Russian. A recently published booklet which was issued to visitors (and which is now available from the Institute) gives details of the organization and current activities of the laboratories.

COAL SCIENCE

THE Second International Conference on Coal Science was held during May 1–4 at Valkenburg, a holiday centre in Limburg, The Netherlands. In keeping with the atmosphere, meetings were held in a conference hall attached to one of the newer hotels, and members were entertained by the Burgomaster, F. A. A. H. Breekpot, at a reception in the Municipal Grotto. The purpose and background of the present biennial series of conferences have already been set out in *Nature* (176, 103; 1955).

The response to the requests for contributions showed that interest in the subject is still increasing. Ten countries were represented as compared with eight on the previous occasion, including the first from the Eastern bloc, namely, Poland, which sent four delegates headed by Prof. Roga, of Glowny Instytut Gornictwa, Katowice. Dr. M. Samec, director of the Kemični Inštitut "Borisa Kidriča", Ljubljana, attended as official delegate of the Slovene

Academy of Arts and Sciences. Coal scientists from Czechoslovakia had also intended to participate but were unable to obtain visas in time. The United States (both Government and industry) was directly represented for the first time. The great majority of conference members, however, were drawn from Germany, France, The Netherlands and Great Britain. Despite efforts on the score of efficiency to limit the numbers attending, the total was about 30 per cent higher than that at the previous conference.

On this occasion changes were made in the arrangements. Meetings took place in the morning and evening, leaving the afternoon free for informal contacts and excursions. All papers were concerned with experimental advances and none attempted to survey a whole field of research. Papers were photocopied in their language of origin, and sent to participants some weeks before the meeting; submission of written summaries of contributions to the discussion in advance was encouraged, so that some indication of the degree of interest in each paper was available to those planning the time-table. Authors were encouraged, on the whole with success, to present their papers in fifteen minutes on the assumption that they had been read in detail by those interested. These arrangements minimized the language difficulties which, however, were still noticeable when the time came for spontaneous discussion and authors' replies.

As on the previous occasion, members of the organizing committee took the chair in turn at the six sessions that followed the address of welcome by the president, Prof. D. W. van Krevelen. The subjects discussed were grouped under four headings: (*A*) chemical methods of coal research (chairman, E. H. Grand'ry); (*B*) new physical techniques in coal research (Dr. M. Th. Mackowsky); (*C*) physicochemical studies of coal macerals (two sessions, Dr. I. G. C. Dryden and Prof. W. Fuchs); (*D*) fundamentals of coal carbonization (two sessions, R. Loison and Dr. D. C. Rhys-Jones).

The proceedings, including discussion, will be published in *Brennstoff-Chemie*, and in view of this it will be sufficient here to direct attention to selected points of novelty or special significance. A notable feature of the Conference was the increased proportion of work based on new approaches and departing from traditional lines of coal research. This healthy sign was the subject of comment, and it was felt by many that the Conference was one of the most satisfying of its kind in recent years.

A contribution by P. H. Given (British Coal Utilisation Research Association) was aimed at elucidating some of the factors controlling the reactions of coal with chemical reagents; he was able to show that the molecular-sieve properties of coals were of secondary importance in hindering reaction, and that where an expected change failed to take place, plausible chemical reasons could be suggested. Using some reagents, in particular bromine, the rate was as high with coal as with simple compounds thought to resemble it in structure. Perhaps the most significant of the results cited in a paper by J. J. Th. M. Geerards, D. W. van Krevelen and H. I. Waterman (Delft) was the production from cellulose in good yield of an oil resembling perhydrophenanthrene in analysis and infra-red absorption; an observation which suggests that the study of primary hydrogenation products may throw but little light on the constitution of an unknown material.

D. E. G. Austen and D. J. E. Ingram (Southampton) discussed recent work on the stable or trapped free radicals detected by electron resonance in coals and carbonized coals. These are few in number (about one to several thousand carbon atoms), and the proportion depends chiefly on the type of coal and temperature of carbonization. Their place in the chemical picture of coal and their influence on its properties are not yet clear. A paper by C. L. M. Bell, R. E. Richards and R. W. Yorke (Oxford) was also presented by Dr. Ingram. Interpretation of nuclear magnetic resonance measurements in terms of the linkages of hydrogen in coal is limited since the forms that can be distinguished are not grouped in the most convenient manner to answer key chemical questions, such as the ratio of aromatic to non-aromatic hydrogen. The preliminary results given did not agree closely with those deduced from comparisons of the intensities of infra-red bands, but in view of the uncertainties in both methods of deduction the discrepancy is more apparent than real. R. Westrik, of the Netherlands State Mines, contributed a study of coals by electron diffraction, which indicated in all samples an unexplained hexagonal spacing twice as large as that of graphite.

Historically there has been a tendency for the coal petrologist and the coal chemist to think on quite different lines and to work in separate compartments. In the papers of Session *C* substantial attempts were made to relate the two fields of inquiry more closely. The long-standing question of the relative merits of the use of polished surfaces and thin sections in the microscopic examination of coal was again discussed and some agreement was evident; it is clear that the methods are to some extent alternative, but also in some measure complementary to one another. Another noticeable tendency was the change in emphasis from discussion of the properties of rock types (the visible banded components of a coal seam) to those of the more fundamental macerals (microscopic components that may be compared with inorganic minerals). D. G. Murchison (Durham) described some well-planned experiments designed to settle a controversy that has long thwarted the effective use of reflectance measurements in the classification of coals: he concluded that variation of the reflectance of the basic microscopic constituents, vitrinites, as a function of their carbon content or rank, was probably not discontinuous.

Papers by A. Ladam, P. Iselin and B. Alpern (Centre d'Etudes et Recherches des Charbonnages de France), by C. Kröger (Technische Hochschule, Aachen), and by F. J. Huntjens, H. N. M. Dormans and D. W. van Krevelen (Netherlands State Mines) were all concerned with the properties, or the thermal decomposition products, of maceral concentrates. A measure of agreement is now apparent and one can indicate in semi-quantitative terms the relations between the chemical properties of a coal and the relative proportions of macerals in it. There are one or two surprising discrepancies between different investigators, but the difficulties are many: if separation is to be at all complete the coal has to be finely sub-divided, and it is then more difficult to express the microscopic analysis in terms of the normally recognized constituents because characteristic shapes and opacities have been modified. The authors of the last two papers mentioned have made especially comprehensive studies.

B. Lavrenčič (Kemični Inštitut "Borisa Kidriča," Ljubljana) gave an interesting account of the rheological properties developed when the unusual Yugoslav coals containing about 10 per cent of organic sulphur are heated; these coals have properties quite abnormal in comparison with classifications based on low-sulphur coals. D. W. van Krevelen, H. A. G. Chermin, H. N. M. Dormans and F. J. Huntjens described the dilatation of various blends of coals and coke on heating and its prediction from that of the components. Two papers, given by I. G. C. Dryden and K. S. Pankhurst (British Coal Utilisation Research Association), and by G. J. Pitt (National Coal Board), are usefully considered together, since the method of extracting, with chloroform, fusible material developed by coking coals on heating was common to both investigations, though in the second investigation scavenging by gas during the heating was considerable and in the first was eliminated as far as possible. A comparison of the two sets of results is of interest: for example, the rate of development of plasticity on heating at constant temperature (Pitt) is much smaller than that of the development of chloroform-soluble material by thermal decomposition. This indicates that the chloroform extract, though known to be associated with the development of plasticity, is by no means the only factor involved.

E. A. Depp and M. B. Neuworth (Pittsburgh Consolidation Coal Co.) discussed the pyrolysis of model compounds thought to embody the type of chemical structure that exists in coals. Interesting results were obtained, but the work is laborious and more variants of structure are needed before drawing firm conclusions; moreover, the existence of a few specially weak linkages in coal may determine the temperature and course of decomposition and to some extent invalidate comparisons with simple pure compounds (compare the different behaviour of synthetic polymers from that of their monomers). Prof. M. Letort (Nancy) presented a most interesting paper on a new type of adsorption isotherm (methane on graphite) which appears to show discontinuities corresponding to completion of successive molecular layers of adsorbate. Prof. Letort suggested that the necessary condition was a special correspondence between atomic spacings in the adsorbent and adsorbate, and that the method could be used to follow the development of graphitization in carbonaceous solids when heated.

Finally, those attending were privileged to see a remarkable colour film made by W. Spackman, W. F. Berry and A. H. Brisse in the United States which showed the behaviour of certain coal constituents on heating thin sections under the microscope. This was not only fascinating to watch but enlightening as to the different interactions between constituents that must occur prior to the formation of coke.

There was some private discussion as to the future value of conferences on coal science in view of the impact of atomic energy. There seems, however, little doubt that the use of coal will be maintained for several decades to come—in the United States it is expected to increase considerably—and that the emphasis will shift from combustion towards chemical conversion. The success and liveliness of this conference encouraged the view that further meetings were desirable at least in the immediate future. It is generally agreed that nowadays conferences proliferate too freely, and it is certainly necessary to examine carefully the reasons even for maintaining an existing series. There is room for much experiment in methods of organizing, particularly in order to reduce the work involved for both organizers and participants, and the amount of irrelevant and repetitive material that has sometimes to be read before the real points for discussion become apparent. This meeting was partly successful in these respects; it is hoped that further improvements can be made on the next occasion. I. G. C. Dryden

MUSEUMS ASSOCIATION

ANNUAL CONFERENCE

THE sixty-third annual Conference of the Museums Association was held in Bristol during July 8–12 under the presidency of Sir Philip Hendy, director of the National Gallery. Nearly four hundred delegates attended, and the Conference opened with a conducted tour of historic Bristol and an informal reception at the University, where members were received by the vice-chancellor, Sir Philip Morris. The official welcome by Alderman Percy W. Raymond (Lord Mayor of Bristol) was followed by a vigorous address from Sir Philip Hendy, who dealt with various activities within the museum movement during the past year. He referred to the successful outcome of the negotiations between the Durham County Council and the trustees of the Bowes Museum at Barnard Castle, and also to the slow progress of talks with the government officials regarding State aid to museums. The plight of some of the smaller museums was described as desperate, and although Sir Philip felt that the nation as a whole was far more museum-conscious than ever before, there was a lack of sympathy in Treasury circles. He felt that there should be a far more equitable distribution of cultural benefits among the organizations and institutions concerned.

The same theme was followed in an afternoon session under the chairmanship of Sir Mortimer Wheeler, who said that in spite of the Treasury's declaration to the contrary, the problem was not purely local, but a part of a general national educational problem. He recalled the scheme in Wales for mutual aid and affiliation between the National Museum of Wales and the museums of the Principality, and considered that it might serve as a model for other regions. Dr. Dilwyn John then outlined the Welsh scheme to which nineteen museums now belong, and Mr. S. D. Cleveland suggested a pilot survey in one part of Britain which might lead the way to a more general plan. Sir George Dyson, chairman of the Carnegie United Kingdom Trust, said that the first step must be to obtain common agreement between the various public and private authorities concerned. Mr. Philip James directed attention to the plight of many museums and art galleries owned by private trusts or societies, and emphasized the importance of ventilating these matters in the Press. Other speakers stressed the urgency of the situation, and in summing-up Sir Mortimer Wheeler said that he felt that a survey carried out in a relatively restricted area, such as south-west England, would yield information of value. Based on that experience, it would be possible to extend the survey to the whole country. As suggested by Mr. W. J. Deacon, it might be possible for

regional museum boards to be formed and to base their constitution on the regional advisory boards of the Ministry of Education.

During the Conference the whole of one day was devoted to museums in the Commonwealth, this being an especially appropriate subject to discuss in the seaport of Bristol. It was a particularly interesting session, and the problems of struggling institutions in distant lands was considered under two headings: first, building, administration and finance; and secondly, training of staff. Speakers from Canada, India, Sarawak and various parts of Africa contributed to a stimulating discussion, and for comparative purposes there was a paper from Miss Toby Rose, of New York. In the majority of cases finance was not the major difficulty and most speakers agreed on the greater difficulties encountered in the training of staff. Dr. D. B. Harden, chairman at this session, announced that both South Africa and Canada had initiated training schemes for the diploma of the Museums Association. It was suggested that the Museums Association should appoint an honorary overseas officer who would have the services of a salaried official. It was considered important that a public demand for museums should be created and that they should be aware of these institutions.

Another session was devoted to scientific and technical problems under the chairmanship of Dr. H. J. Plenderleith. Dr. W. E. Swinton described the progress in these matters that he had recently seen in the United States. Dr. A. E. A. Werner, of the British Museum Research Laboratory, who followed, dealt with the subject of heating and ventilation. He first discussed the cardinal principles which must be observed if damage due to unfavourable environmental conditions is to be avoided, and pointed out that it was necessary not only to maintain the atmospheric relative humidity within reasonable limits—the minimum being 45 per cent and the maximum 65 per cent—but also to prevent rapid changes in humidity, particularly in art galleries where panel paintings are exhibited, as well as to ensure continuous and adequate air circulation around the museum objects. The practical problems involved in the control of relative humidity, air circulation and also air cleaning to remove harmful atmospheric pollution were outlined, and this was followed by a brief description of the various types of standard self-contained units that are commercially available for complete or partial air-conditioning. Emergency methods that can be used in stores and repositories, involving the use of simple apparatus such as electrically heated tea-urns and fans, were described. The importance of having some means for continuous recording of relative humidity (and of temperature also) was emphasized, and attention was directed to the precautionary measure of using a sling psychrometer to detect air pockets in which a high relative humidity may build up and encourage both mould growth and metallic corrosion.

Mr. W. E. Rawson-Bottom (Ministry of Works), after a brief review of the evolution of museum lighting from the days of the 'fish-tail' gas burner, stated that at the present time developments were proceeding rapidly chiefly because it is recognized as an essential aid to display. Museum lighting is a problem for the co-operation of the lighting engineer, architect, display designer and curator, and it is essential that attention should be directed to the exhibits rather than to bare lamps or fittings of high brightness. In other words, lighting should produce an effect without an apparent cause. One method is to use a type of louvre fitting. In case lighting, not only are the position and colour of lamps important, but also the selection of background colour.

Mr. B. S. Cooper (Research Laboratories, General Electric Co.) directed attention to some recent work on the fading and tendering of dyed fabrics, and pointed out that the humidity requirements most suitable for minimizing fading might well be far from the optimum in respect of loss of strength of the fabric. He also pointed out that in considering possible photochemical hazards to exhibited material, the level of illumination was usually a far more important factor than the spectral character of the light used.

At the annual general meeting Sir Philip Hendy was re-elected president for 1957–58; it was decided to hold the next annual meeting in July 1958 in London and to invite Museum Dag from The Netherlands to take part. Honorary fellowship of the Association was bestowed upon Dr. Paul Coremans, of the Central Laboratory of Belgian Museums, Brussels, and others, including Dr. H. C. Blote, of Leyden, Holland, were elected to fellowships.

F. S. Wallis

LARGE TELESCOPES

Dr. R. v. d. R. Woolley, the Astronomer Royal, delivered the James Forest Lecture to the Institution of Civil Engineers on May 14 on the subject of "Large Telescopes". Dr. Woolley dealt with the different kinds of telescope and their mountings and with the construction of domes and the methods for rotating them. He then explained the serious difficulties—and the methods adopted for circumventing them—encountered in large telescopes, owing to flexure in the glass of the mirror, and also flexure in the tube itself. When all these troubles have been overcome, there are still serious limitations even with the largest telescopes, some examples of which were given. For first-class stellar spectra the 200-in. telescope at Mount Palomar will only go to magnitude 8 and to magnitude 12 for reliable radial velocities.

Some years ago a number of British astronomers launched a project for building a 100-in. telescope, and obtained Government approval in principle for financing the scheme. This Isaac Newton telescope will be situated at Herstmonceux and will, it is hoped, be completed by 1962. The sky at Herstmonceux is, as England goes, remarkably good, and as Dr. Woolley says, "It is hoped that the Isaac Newton telescope will do much to promote a vigorous resurgence in the practical as well as in the theoretical problems of astronomy in this country". Informing his audience that science and scientific techniques are closely interlocked, and that even if astronomers fail to convince the public that large amounts of their money should be devoted to the disinterested survey of the heavens, he proceeded: "We may remind them that in this technical age, survival as a first-class nation can only be secured by a thorough realization of the fundamental importance of science and technique. As an integral part of this, we may urge the importance of astrophysics: and as an essential tool of astrophysicists, astronomers feel justified in calling for public support for large telescopes".

CO-ORDINATED RESPONSE TO STIMULI IN CORAL POLYPS

WITH the assistance of an award from the Commissioners for the 1851 Exhibition and of a grant from the Royal Society, Dr. G. A. Horridge left the cold waters of the North Sea for a period of two months to visit Ghardaqa on the Red Sea, in order to study the response to contact stimuli of corals living in that warm sea. A report of this work has recently been published*. The term coral includes so many subclasses, orders and families that no conclusions regarding response can be formulated which will apply to all of them. Most corals expand only in darkness and do not keep well under artificial conditions, so that Dr. Horridge worked chiefly at night, with a dim light, and used fresh material for each experiment. Electrical stimulation was based on the discharge of a condenser as described by Pantin, and the number of polyps which began to retract was recorded visually. The progressive spread of excitation across the colony in response to successive shocks at short regular intervals was observed. To take two examples: in a gorgonid (*Acabaria pulchra*) a stimulated tentacle reacted, and the retractions gradually spread to neighbouring tentacles, until all the tentacles of one polyp had contracted symmetrically, but unlike other corals there was little co-ordination between the polyps of the colony. In *Tubipora*, on the other hand, there is a highly correlated conducting system, although this is subject to the intensity and repetition of the stimulus. In more than a dozen species studied, however, it was found that the individual polyps possess a conducting system which co-ordinates their retraction through the mesenteric muscles. At first the reaction is slow, requiring a second shock to activate it fully, and causing a jerky wave of polyp retraction, differing from the slower and more continuous feeding response.

A working model was constructed to illustrate the effect of conducting and non-conducting units in inter-neural facilitation in a two-dimensional net, using a perforated board with movable pegs. The non-conducting unit is assumed to be so "at the instant when an impulse arrives", but the connexion "becomes conducting for later impulses which may arrive within a specified time". Experiments with the model, however, do not coincide with those on the living colony in certain species, the spread of excitation in which is less than that in the model. To account for this variability a second model was used. The nerve net is now considered as a population of cells, and an impulse excites only a proportion of the cells in a group. In some species, and in others after low stimulation, there was no interaction between units; in other species the wave of excitation spreads when more than a critical number of units is stimulated.

The inter-neural facilitation theory of Pantin assumes an all-or-nothing response, in which a series of separate units forms, for the time being, a continuous pathway. This theory is inadequate for the corals, and requires modification along the lines suggested by Dr. Horridge. Yet all theories await histological research on the nerve net of corals.

N. B. EALES

* Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 675, Vol. 240 (9 May, 1957): The Co-ordination of the Protective Retraction of Coral Polyps. By G. A. Horridge. Pp. 495–529. (London: Royal Society, 1957.) 12s.

THE EUROPEAN BADGER

SOME interesting observations on tame and wild badgers (*Meles meles meles* (L.)) have been made by John Sankey, of the Juniper Hall Field Centre at Dorking (*South-Eastern Naturalist and Antiquary*, 60, 20; 1955).

The tame badgers were kept in captivity primarily to obtain information on their breeding cycle and habits. This has not yet been possible, but other information, otherwise difficult or impossible to get by watching the animals in their natural habitats, is recorded in the paper.

All the animals were obtained within six to about eight weeks from birth. At about two months the cubs emerge from the sett for the first time, and older badgers have usually been so conditioned to their natural life that it is impossible to tame them. Young animals taken before or at this critical point of development will readily take to a human, and, by frequent handling and attention, become very tame. Their reactions to certain situations are often remarkable and amusing. Badgers vary in their temperament, the females probably being more equable.

The badgers thrived on a variety of foods, and the diet could be varied within wide limits.

From observations on eight females and seven males the average weight of a badger about eight weeks old was found to be 4½–5 lb. The difference in weight between the sexes does not appear to be significant at this stage, and any deviations from the normal might be due to other heredity or nutritional causes.

From specimens reared, but not born, in captivity the weights of the adult male and female differ more. The male is, on an average, a little more than four pounds heavier than the female. These badgers appeared to be fully grown, but not necessarily sexually mature, about the autumn of their first season. Little increase in weight occurred from then onwards.

Badgers lose some of the smaller white hairs during the first summer, and the longer, thicker hairs are gradually replaced. A noticeable moult occurred from the beginning of June and lasted for several weeks. This appears to be the badger's annual moult. Scratching is intense during this period, and the hair may be shed in quantity.

Several of the captive animals died when young, mostly before eight weeks. Since their former life is unknown, that is, at the time when they were dug out or where caught in some other way, little can be deduced about their resistance to disease, though two cubs succumbed to a pneumonic infection which they had contracted previously.

There is little information about whether badgers do bathe in pools, ponds and rivers. Observers agree that badgers drink water, and this was confirmed by the captive badgers. Bathing is recorded in the case of three males and three females, but only during summer. One female began to go into water at about five months, and all the others bathed during their first summer. When the weather is warm, a bath is taken regularly. It seems very probable that wild badgers go into water regularly in the summer months. Badgers keep their faces very clean. The action is similar to that of a cat; the paw is licked and wiped over the face.

All the badgers reared beyond eight weeks have retained the natural habit of "setting scent" in captivity. Scent may be frequently set on the same

object, such as a man's shoe. Unfamiliar objects interest the badger; but the fact that scent is set on familiar things, on which it was set perhaps only a few moments before, is difficult to explain.

The scent appears to serve the purpose of marking out territory and to enable the creature to locate its whereabouts. There appears to be no difference in this habit between male and female even when kept together. Nor is there any modification in the setting of scent in the presence of dogs and tame foxes. Fear causes the sudden release of musk in tame badgers. The fluid is milky-yellow and of moderately thick consistency.

Only four sounds have been noted in the case of tame badgers. First, there was a persistent rhythmical whimpering in young specimens which was nearly always followed by death; this was apparently a note of discomfort or pain. Secondly, there was a low continuous guttural purr produced when food was smelt, or when the animals wanted attention; this was probably a conditioned feeding request. Thirdly, a deep-throated muffled growl, which was clearly a note of warning, and sometimes followed by attempted attack. Fourthly, there were puppy-like yelps used only during play, and more especially in juveniles up to about six months.

The badgers were reared and kept on an artificial diet. Small quantities of vitamins and salt were added to the food from time to time. The food taken confirms the badger's omnivorous nature. Meat is undoubtedly preferred, and sweet things are greatly liked. One female badger drank small quantities of mild ale, and a male on several occasions lapped sweet wine. A number of natural foods were tested —among them being earthworms, insects (some showing aposematic colours) and molluscs. Most of these (including some insects with aposematic colours) were eaten, with the exception of the Roman snail (*Helix pomatia* L.).

In his observations on wild badgers Sankey showed that badgers can become conditioned to the presence of man; little attention need be paid to whether the badgers smell the observers.

Badgers pick up food anywhere, but usually have fairly well-defined feeding grounds; there is a definite pattern of tracks from the colonies to the feeding grounds. Dung pits are concentrated near the setts or the feeding grounds, and are seldom seen elsewhere. Yew berries appear to be eaten fairly liberally in the autumn but are often regurgitated.

The loud "blood-curdling" noise described by Neal has been recorded, and supports Neal's opinion that this call has no sexual significance; it does not preclude the possibility that on occasion it can be used to attract from a distance an animal of the opposite sex. The observations also suggest that the sound has nothing to do with the dismissal of the cubs.

The article also contains an account of an old badger-baiting pit.

AN ELEMENTARY THEORY OF INTERSPECIFIC COMPETITION

By M. H. WILLIAMSON

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THE proposition known as Gause's hypothesis is often stated so as to imply that two species cannot remain in competition indefinitely. In the mathematical theory of competition cases occur in which two competing species can coexist. The word 'niche' has been used in discussions on this subject, but not in such a way that it can be applied unambiguously to field data. It would therefore seem worthwhile to restate and develop the mathematical theory so that its relation to particular situations in the field is more readily apparent. Before this can be done, it is necessary to discuss what is meant by the word competition. There are almost as many definitions of competition as there are authors who have written on the subject, and it would be pointless to mention all the variants that have been proposed. Instead, an argument will be developed which leads to a definition that can be treated mathematically, and comments on other definitions will be given during the argument.

The usual meaning of a word must be considered when defining it for scientific use. No doubt Andrewartha and Birch[1] had some such idea in mind when they said that "The literal meaning of 'compete' is 'together seek'". This is not the literal meaning of compete but a literal translation of the Latin *competere*, which means to coincide. The Concise Oxford Dictionary gives 'strive with another' as a possible meaning of compete, and this suggests that there are three properties that must be included in a definition for use in ecology. These are: (1) that competition is mutual or reciprocal; (2) that it is harmful; (3) that the action of A on B is of the same type as the action of B on A.

Properties 1 and 2 are equivalent to the definition given by Odum[2], when he says that the effect of population growth and survival of species A on species B is negative and the effect of B on A is also negative when they are in competition. Elton and Miller[3], by saying "*Interspecific competition*, in the more limited and correct use of the notion, refers to the situations in which one species affects the population of another by a process of *interference*, i.e., by reducing the reproductive efficiency or increasing the mortality of its competitor. Or both species may be acting in such a way on each other", deliberately exclude property 1; but it is difficult to distinguish between some cases that they would call competition and, say, predation. The bearing of (3) on ecology can perhaps be clarified by an imaginary example. Suppose that a population of predators, say, dogs, are feeding on a population of prey, say, rabbits. Suppose also that many of the dogs are poisoned by eating the rabbits. Then the effect of the dogs on the rabbit population and the effect of the rabbits on the dog population would both be negative, and so by Odum's definition the species are in competition, although the situation is not one which most people would consider to be competition at all.

At this point it is necessary to define the term 'controlling factor'. By this is meant a factor which acts more severely against the individuals of a popula-

tion when the population increases, and which has an appreciable effect, and so tends to control the population size. This is often known as a density-dependent factor; it is called a "concurrent density-dependent factor" by Solomon[4] and a "negative density-dependent factor" by Haldane[5], but factors could exist with the right density relationships but which nevertheless would never act at densities reached by the population in practice. The theory of the control of populations by controlling factors has been understood for a long time; it was, for example, stated clearly by Wallace[6], and a simple statement of the case is given by Moran[7]. Andrewartha and Birch[1] seem to think that controlling factors are unnecessary because environments vary. In fact this variation makes them more important, in the same way that a car needs more steering on a rough road than on a smooth one. In a deterministic system a species with birth- and death-rates equal to one another persists indefinitely, while in a stochastic system it inevitably becomes extinct[8], if it is not controlled.

Crombie[9] and others have realized that interspecific competition involves controlling factors, as increases in density will intensify the mutual harmful effects. Competition between two species A and B could then imply either that both have a controlling factor in common or that A acts as a controlling factor for B and vice versa. The second possibility would almost certainly involve each species acting as its own controlling factor as well, and so reduces to a special case of the first. One can say then that two species are in competition when they have a controlling factor in common, and conversely, if two species are in competition they have a controlling factor in common.

This definition is precise and yet broad. It includes the competition in which each species attacks the other, it includes competition for food or sites, and it also includes competition to avoid an enemy, to avoid a predator, a parasite or a disease, that is, cases in which two victim species are in competition because they are both controlled by the same enemy. The observable results of all these types of competition will be much the same, and it is inconvenient to be able to identify a process and yet not give it a name. Those who would like a narrower definition must invent some term to cover competition as defined here, while it is easy enough to restrict discussion to certain classes and still keep the broad definition by talking about, for example, competition for food.

Most of the rest of this article is devoted to a consideration of the consequences of competition in some simple situations. The bearing of these results on more complicated and realistic situations is discussed shortly at the end. The following assumptions are made: (1) Individuals are all alike: no sex, age or genetic distinctions are recognized. (2) The environment is uniform in time and space. (3) The system is closed ecologically, that is, there is no immigration or emigration. (4) The numbers are large enough for deterministic rather than stochastic equations to be used, and for the numbers to be treated as continuous variables. (5) There is no time lag in any effect.

For each species a differential equation will be written in which the left-hand term, dn/dt, represents the rate of change of the population size n in time, while the right-hand side will have one term to represent births and others to represent deaths. It is convenient at first to ignore density effects on the birth-rate and write

$$dn/dt = an \qquad (1)$$

where a is a positive constant, for the birth-rate. For the death-rate from a single controlling factor for a single species write

$$-bnf(n) \qquad (2)$$

where b is another positive constant and $f(n)$ is a monotonic increasing function of n such that, when n is small, $bf(n) < a$, and when n is large, $bf(n) > a$, large and small referring here to values n might conceivably have in a real population. The inclusion of the term n in the expression for a controlling factor ensures, in a system in which more than one species are being considered, that the losses of the population shall be small when the population is small, irrespective of the size of the other populations. This term is arbitrary, and the effect of using other possible terms in its place is considered later.

The equations for two species the whole mortality of which is caused by one controlling factor acting on both of them can be written as

$$\begin{aligned} dn_1/dt &= a_1n_1 - b_1n_1f(n_1,n_2) \\ dn_2/dt &= a_2n_2 - b_2n_2f(n_1,n_2) \end{aligned} \qquad (3)$$

where n_1,n_2 are the population sizes of the two species, a_1,a_2,b_1,b_2 are positive constants and $f(n_1,n_2)$ is a monotonic increasing function, symmetrical in n_1 and n_2, and with $f(n,0) = f(n)$. Because of assumption 1 above, that all the individuals are the same, n_1 and n_2 can be any suitable measures which make $f(n_1,n_2)$ symmetrical. Equations (3) are the same as equations (2) of Chin[10] and can be contrasted with the equations of competition given by Philip[11] and the authors he quotes. These can be written

$$\begin{aligned} dn_1/dt &= a_1n_1 - b_1n_1(n_1 + c_1n_2) \\ dn_2/dt &= a_2n_2 - b_2n_2(n_2 + c_2n_1) \end{aligned} \qquad (4)$$

where c_1 and c_2 are positive constants. It will be noted that these differ from (3) in that the monotonic function in parenthesis is assumed to be linear and that it it is not symmetrical. Consequently the solution of (4), which allows both species to survive, does not exist for (3). Ecologically, (4) does not necessarily represent two species with but one controlling factor, and the use of a linear function has no biological justification.

The solution of equations (3) has been given by Chin and others, and is that if $a_1/b_1 > a_2/b_2$ species 1 will survive and species 2 die out and conversely. For the rest of this paper species 1 will be assumed to survive. The situation is shown in Fig. 1. The axes represent the numbers n_1,n_2. The lines across the figure are the loci of $dn_1/dt = 0$ and $dn_2/dt = 0$, and are drawn as undulating lines as $f(n_1,n_2)$ is only loosely defined. The arrows show the direction of movement of a point representing the joint population in each of the three zones defined by the two curves. When $a_1/b_1 = a_2/b_2$ the curves coincide, and a line of neutral equilibria, analogous to the $p^2 : 2pq : q^2$ equilibrium in genetics, exists. In practice, a_1/b_1 never will be exactly equal to a_2/b_2, but note that the rate of elimination of one species by the other is a function of the difference of these two ratios, and in a stochastic model the species with the smaller ratio would sometimes be the survivor.

Two species, then, each with a constant birth-rate and death caused only by a single controlling factor acting simply on both of them, cannot coexist. Consider next the addition of a second controlling factor acting on both species or just on species 1. This means the addition of another term like (2) to

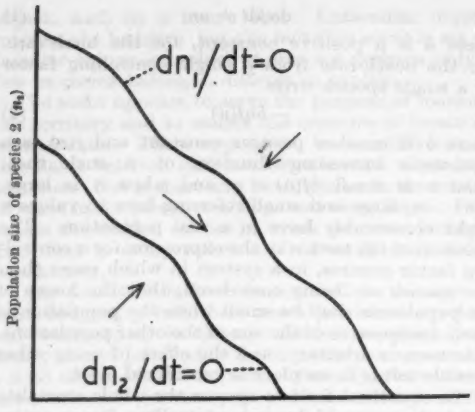

Fig. 1. A diagram to show the course of competition when one species eliminates the other

both or one of the equations (3), or, if the controlling factor acts through the birth-rate, the replacement of a in (1) by a monotonic decreasing function of n, which can be taken as equal to a for small n. In either case the locus of $dn_1/dt = 0$ in Fig. 1 will be moved towards the origin, but the movement will be greatest along the n_1 axis. It is possible that this will make the two curves intersect, giving Fig. 2. Here there is a point of stable equilibrium. This means that if two species are in competition from having a controlling factor in common, it is possible for them to reach a stable equilibrium with both species surviving, provided that at least one other controlling factor is acting. No question of different niches arises. This conclusion can be generalized to a proposition that it is possible to have as many species as controlling factors. If there are more species than controlling factors some must die out, and in many cases fewer species than there are controlling factors will be able to survive. There is no point in proving this general proposition in view of the consequences of complicating the system in other ways which are considered below.

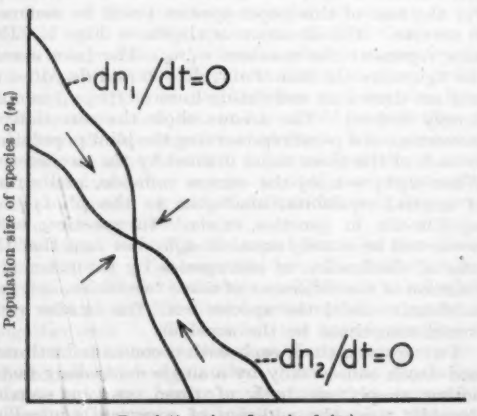

Fig. 2. A diagram to show the course of competition leading to a balance between the two species

As has been mentioned, the term n in (2) is arbitrary; other monotonic increasing functions in n could be used instead. Those that increase faster than n can represent increased preference or habituation by the controlling factor. Rewrite the first equation of (3) as

$$\mathrm{d} \ln n_1/\mathrm{d}t = a_1 - b_1 f(n_1,n_2) \qquad (5)$$

then the locus of $dn_1/dt = 0$, which is the same as the locus of $\mathrm{d} \ln n_1/\mathrm{d}t = 0$, cuts the n_1 axis at the value of n_1, which is the solution of

$$a_1/b_1 = f(n_1) \qquad (6)$$

and the n_2 axis at the value of n_2 which is the solution of

$$a_1/b_1 = f(n_2) \qquad (7)$$

A 'preference factor' can be included in (5) by putting another monotonic increasing function of n_1, say, $g(n_1)$, in the last term. If $g(0)$ is taken as 1, then the intersections of $dn_1/dt = 0$ with the axes become the solutions of

$$a_1/b_1 = f(n_1)g(n_1) \qquad (8)$$

for the n_1 axis, and

$$a_1/b_1 = f(n_2)g(0) = f(n_2) \qquad (9)$$

for the n_2 axis. $g(n_1)$ must be greater than one, so the solution of (8) is less than the solution of (6). The situation in Fig. 2 is again possible, and would of course still be possible if $g(0) \neq 1$. This time two species are in stable equilibrium although there is but a single controlling factor which acts on both. An example of this would occur if two species of snail were controlled by a single species of bird, and if the bird tended to prefer whichever snail was the commoner. Both species of snail could persist.

Terms can be added to equations (3) to represent deaths not caused by controlling factors. If an inverse density-dependent factor, a factor which causes more deaths at low densities, is included the curves of Fig. 1 can be moved so as to intersect and give a point of unstable equilibrium. Indeed, functions representing the controlling and inverse density-dependent factors could be found so that the loci of $dn_i/dt = 0$ intersected more than once, giving a series of stable and unstable equilibria, so producing another case in which two species with but one controlling factor could coexist. Such a case would not occur with functions which are likely to be found in real communities.

What would be the consequences of competition if the five assumptions listed above were abandoned? In the simple cases considered here, survival of both competitors becomes easier and more likely as more variables are considered. Further complications are likely to have the same effect, except that stochastic systems may well have fewer effective equilibria. For example, Nicholson[12] in his proposition C 12 says, "if several species of specific parasites attack a common host species in succession, the steady state may exist", or in the terminology of this paper, several species can coexist when they all have the same controlling factor and no other controlling factors if the factor acts on each at a different time. Again, Oldham[13] found that only one of the two species of snail *Cepaea nemoralis* and *C. hortensis* occurred on any particular area of sand dunes, although overlapping colonies of these two

species can be found inland[14]. This suggests that the ecological situation on the sand dunes is not complicated enough to allow both species to occur together.

Finally, all systems developed here which lead to a stable equilibrium with both competing species surviving can be adapted to refer to alleles of a single species persisting in stable polymorphism.

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EVIDENCE FROM MOIRÉ PATTERNS OF PACKING FAULTS IN BORON NITRIDE CRYSTALS

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DURING an experimental investigation on the friction properties of lamellar solids, a specimen of crystalline boron nitride was examined in the electron microscope, a Siemens Elmiskop 1. Fringes of widely varying spacing were frequently observed. These were moiré patterns of the type observed by other workers with overlapping crystals (see Pashley, Menter and Bassett[1]). However, the patterns were seen more frequently than would be expected from fortuitously overlapping crystals so the investigation was extended.

The boron nitride containing less than 0·6 per cent impurities was given by Mr. R. S. Pease[2], who prepared it in a white crystalline form. A drop of a suspension of boron nitride in alcohol was dried on a grid covered with a thin carbon film which had been stripped from a cleavage face of mica at a water surface. The plate-like crystallites tended to lie flat on the film, so that the incident electron beam was approximately perpendicular to the basal plane. The planes involved in the production of the moiré pattern are of the type (*hki*0) which are perpendicular to the basal plane. Any slight tilt of the crystals could frequently be corrected by using the stereo-holder to bring the planes into the required diffraction position.

Fig. 1. Moiré pattern from boron nitride in bright field showing several sets of fringes. (× 34,000)

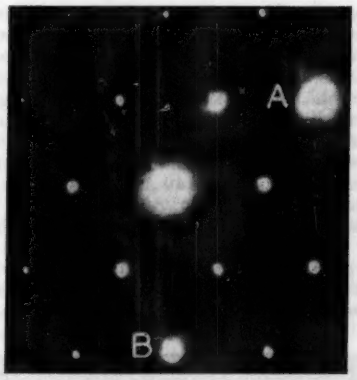

Fig. 2. Diffraction pattern from the area indicated by the circle in Fig. 1

Formation of Fringes with Boron Nitride

The crystal structure of boron nitride was completed by Pease[2]. It has a hexagonal layer lattice ($a = 2{\cdot}504$ A., $c = 6{\cdot}661$ A. at 35° C.). The layers consist of a network of hexagons of composition B_3N_3 and they are repeated along the *c*-axis every 3·33 A. In contrast to graphite, where alternate layers are displaced laterally, the layers in boron nitride are packed directly above one another, so that a perfect crystal may be considered to have a hexagonal array of holes extending through it parallel to the *c*-axis.

Fig. 1 is a moiré pattern from boron nitride showing several sets of fringes. It was obtained using bright-field illumination with a 50-μ objective aperture. The diffraction pattern obtained from the area indicated by the circle, using the technique of selected area diffraction, is shown in Fig. 2. The pattern is printed so that its orientation is the same as the micrograph. Fringes were also obtained in the dark-field image by using the objective aperture to select the diffraction spots *A* and *B*, and are shown in Figs. 3*a* and 3*b*, respectively. The fringes obtained in dark field are almost perpendicular to the planes

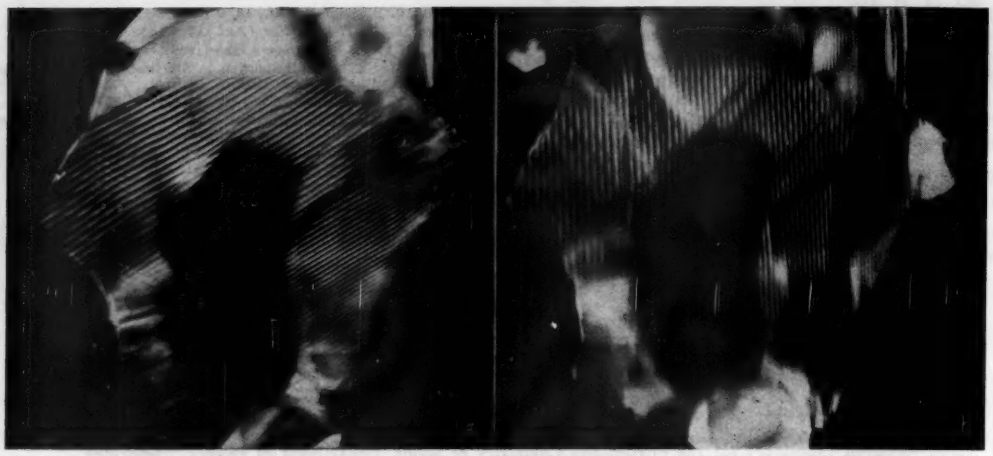

Fig. 3. (*a*) Moiré pattern in the dark field from spot *A* in Fig. 2. (*b*) Moiré pattern in the dark field from spot *B* in Fig. 2. (× 34,000)

of the type $(11\bar{2}0)$ producing them, suggesting that they are formed by two crystals, one of which is twisted about the *c*-axis relative to the other. The dark-field technique has two advantages. The planes producing the fringes can be identified unambiguously, and the contrast is improved considerably since only the beams producing the fringes are allowed through the objective aperture. The planes producing the fringes of spacing about 140 A. shown in the bright-field micrograph, Fig. 4*a*, were identified by the dark-field micrograph, Fig. 4*b*, to be of the type $(10\bar{1}0)$. The increased contrast in dark field clearly reveals a set of fringes of spacing approximately 60 A. on another crystallite which are almost invisible in the bright-field micrograph.

Fig. 5*a* represents two crystals, C_1 and C_2, one of which is rotated through a small angle α about an axis parallel to the incident beam relative to the other. The image observed in bright field is caused by interference of the undeviated beam L with the doubly diffracted beam M. Fringes are formed perpendicular to the planes producing them and the fringe spacing S is given by $S = d/\alpha$, where d is the spacing of the planes involved in the double diffraction (Dowell, Farrant and Rees[3]). The image obtained in dark field is considered to arise from interference of the two primary diffracted beams P and Q. Fig. 5*b* shows a section through the reciprocal lattice of boron nitride perpendicular to the basal plane, and Fig. 5*c* a section through the reciprocal lattice

Fig. 4. (*a*) Moiré pattern in the bright field showing fringes of spacing approximately 140 A. (*b*) Moiré pattern in dark field of same area as Fig. 4*a*. As well as the fringes of spacing about 140 A., fringes of spacing about 60 A. can be seen on another crystal. (× 160,000)

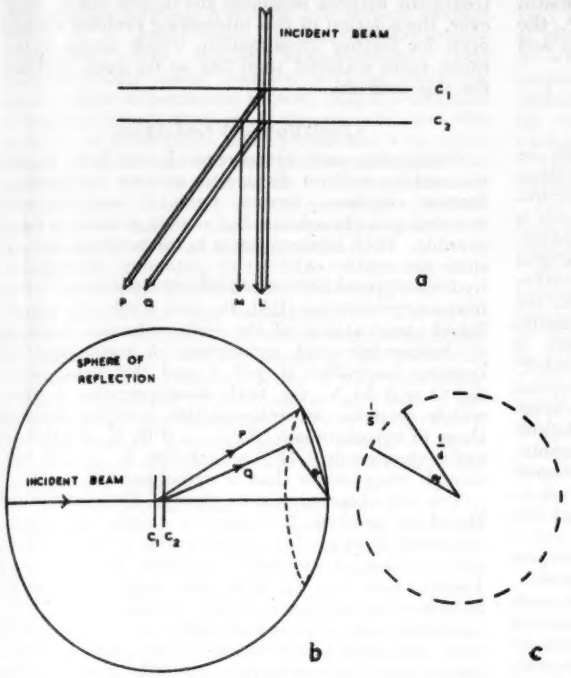

Fig. 5. Formation of fringes in dark field

parallel to the basal plane. The incident electron beam is normal to the basal plane. The beams P and Q combine in the image plane to give fringes of spacing S (cf. Menter[4]) and it is readily seen that in this case also $S = d/\alpha$, where d is the spacing of the planes involved in the diffraction, and that the fringes are perpendicular to the planes producing them.

The angle required to produce the fringes shown in the dark-field photographs 3*a* and 3*b* is too small to enable two spots at A and B to be convincingly resolved in the diffraction pattern. At higher orders more than one spot can be seen, but they are too close together for an accurate measurement of their separation to be made. However, the diffraction pattern obtained from two metal crystals shown by Pashley, Menter and Bassett[1] demonstrates that in favourable circumstances each diffraction spot can be resolved.

Frequently fringes were observed when there was no obvious overlapping of two separate crystallites. The fringes with a spacing of approximately 60 A. shown in Fig. 4*b* using the dark-field technique are a typical example. From his X-ray powder photographs, Pease showed that the crystallite thickness deduced from the breadths of the (*hkil*) lines was smaller than that deduced from the breadths of the (000*l*) lines. He inferred that the boron nitride crystallites have packing faults consisting of a displacement of the layers perpendicular to the *c*-axis. The present results indicate that the fringes observed in many cases arise from a packing fault involving a small angular twist about the *c*-axis. Many of the micrographs (for example, Fig. 1) show fringes with various types of discontinuities which may be interpreted as imperfections in the crystals.

I thank Dr. F. P. Bowden for his interest and advice. Thanks are also due to Dr. D. W. Pashley and Mr. M. Camp for helpful discussions, Mr. R. S. Pease for the boron nitride, Mr. C. K. Jackson for assistance, Acheson Colloids, Ltd., for a research fellowship, and Industrial Distributors, Ltd., for a grant to the laboratory.

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PROPERTIES OF HELICORUBIN AND CYTOCHROME *h*

By Dr. JOAN KEILIN
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HELICORUBIN, which is an extracellular hæmochromogen found in the red fluid contents of the digestive tract of land snails, was first observed in 1876 by Sorby[1], and its reversible oxidation and reduction *in vitro* as well as some of its spectroscopic properties have been described on the crude material obtained from snails[2]. The pigment has been found to be widely distributed among molluscs, crustaceans and polychætes[3].

Helicorubin and a very similar hæmochromogen found in the digestive gland (hepatopancreas) of the snail *Helix pomatia* have now been purified by methods described in detail elsewhere[4]. The intracellular hæmochromogen from the digestive gland has been provisionally named 'cytochrome *h*', since it was found to differ in certain respects from helicorubin and to have several properties in common with the cytochromes belonging to the *b* and *c* groups.

Purified helicorubin and cytochrome *h* were found to be homogeneous on moving-boundary electrophoresis, and their electrophoretic mobilities showed that both hæmoproteins are acidic, their isoelectric points lying below *p*H 4·3. Sedimentation studies in the ultracentrifuge showed in each case only one symmetrical, slowly sedimenting boundary. From the sedimentation and diffusion constants their molecular weights were found to be about 18,000. Their colours and absorption spectra in the oxidized

and reduced forms are those of typical parahæmatin and hæmochromogen compounds respectively[4], the α-band of reduced helicorubin lying at 561·5 mμ and that of cytochrome *h* at 556 mμ.

Separation of the Prosthetic Group from the Protein

The prosthetic group of helicorubin can easily be separated from its protein by treatment with acetone containing 0·1–1 per cent v/v of concentrated hydrochloric acid and at room temperature the reaction is complete within a few minutes. The almost colourless precipitate of denatured protein is centrifuged off, leaving a clear peach-coloured acetone solution of acid hæmatin which is soluble in ether. On the addition of sodium hydroxide and sodium dithionite to the acid hæmatin, its absorption spectrum is replaced by that of the dihydroxyhæm compound[5]. The latter, in the presence of pyridine, gives a typical pyridine hæmochromogen with an absorption spectrum indistinguishable from that of pyridine hæmochromogen obtained from crystalline protohæmin, the positions of the two bands in the visible region being: α, 558 mμ; β, 528 mμ. These findings are in agreement with some of the results recorded by Dhéré, Vegezzi, Anson and Mirsky[2].

Although in cytochrome *h* the prosthetic group is more firmly linked to the protein than in helicorubin, it can nevertheless be split off by treating it with acetone containing 4 per cent v/v of concentrated hydrochloric acid giving a clear acetone solution of ether-soluble acid hæmatin, or by pretreating it with aqueous 0·5 *N* hydrochloric acid followed by the addition of acid acetone. However, the α-band of the pyridine hæmochromogen prepared from this hæmatin lies at 555 mμ, that is, 3 mμ nearer the blue end of the spectrum than the α-band of pyridine protohæmochromogen.

Considering that the prosthetic group of cytochrome *h* is much more firmly linked to the protein than in other hæmoproteins with the exception of the *c* group of cytochromes, that it can nevertheless be separated from its protein by acid–acetone treatment and that the absorption bands of its pyridine hæmochromogen lie nearer the blue end of the spectrum, one may suggest that it is a somewhat modified protohæmatin not necessarily deprived of both its unsaturated vinyl groups in positions 2 and 4 of the porphyrin. Were these groups joined to the two cysteine residues of the protein by thioether linkages as was shown[6] for cytochrome *c*, or condensed in any other way with some other amino-acid residues of the protein, the α-band of the pyridine hæmochromogen given by such a hæm would lie at about 550–551 mμ (that is, close to the α-band of the pyridine hæmochromogen obtained from meso- or copro-hæm[7]) and not at 555 mμ as was found experimentally; neither would the prosthetic group be separated from its protein by acid acetone giving a clear acetone solution of acid hæmatin.

Two suggestions can be offered as to the possible nature of the prosthetic group of cytochrome *h*: (1) it may be a protohæmatin which has undergone a minor change, not yet properly understood, which is known to occur in protohæmatin dissolved in weak alkalis such as sodium carbonate or phosphate after standing for a day or two[8]; or (2) it may be a protohæmatin in which only one of the vinyl side-chains is linked to an amino-acid residue of the protein but can nevertheless be split off by comparatively mild treatment without regaining the double bond. However, the solution of this interesting problem remains open for further investigation, which would require much more material than has so far been available for this purpose.

Oxidation and Reduction

Helicorubin and cytochrome *h* are both readily reduced by sodium dithionite, sodium borohydride, ferrous sulphate, ferrous oxalate, ascorbic acid, cysteine and glutathione but not by potassium ferrocyanide. Both hæmoproteins in the reduced (ferrous) state are readily oxidized by potassium ferricyanide, hydrogen peroxide and ferricytochrome *c*. Preliminary estimation (Hill, R., and Keilin, J., unpublished observations) of the oxido-reduction potential of helicorubin and cytochrome *h* using naphthoquinone as buffer at *p*H 7 and 24° have shown $E_0' = +0{\cdot}20$ V. for both hæmoproteins, a value which occupies an intermediate position between those of cytochrome *b* ($E_0' = -0{\cdot}05$ V. at *p*H 7·4)[9] and cytochrome *c* ($E_0' = +0{\cdot}266$ V. at *p*H 6)[10], though lying nearer that of cytochrome *c*.

The old observations by Sorby, Krukenberg and MacMunn (see refs. 1, 2) that, in slightly acid gastro-intestinal fluid or 'bile', helicorubin is oxidizable in the presence of air were confirmed by Dhéré and Vegezzi (see ref. 2), who also suggested that its reduction on making the 'bile' alkaline is due to the appearance of reducing substances. These results were confirmed in the course of the present investigation, since it was found that 'bile' made alkaline reduces not only helicorubin but also purified cytochrome *c* added to it. Even highly purified helicorubin preparations (freeze-dried after stage III of the purification[4]) when treated with *N* sodium hydroxide undergo partial reduction, which is probably due to the presence of carbohydrates in these preparations.

The reactions of helicorubin and cytochrome *h* with oxygen were studied over a wide range of *p*H (2–14), and it was found that in acid solutions they become autoxidizable at *p*H 6, the reaction becoming rapid below *p*H 5·5, whereas in alkaline solution they do not undergo autoxidation even when kept in a solution of *N* sodium hydroxide. Cytochrome *h* tested similarly was shown to become autoxidizable at approximately the same *p*H as helicorubin.

Reactions of Helicorubin and Cytochrome *h* in Biological Systems

Both helicorubin and cytochrome *h* react with the components of the respiratory chain of the heart muscle preparation, being reduced on the addition of sodium succinate or of reduced diphosphopyridine nucleotide and oxidized by the cytochrome oxidase system. The reduction of these hæmoproteins may be followed spectrophotometrically as described[11] for cytochrome *c*; but the concentration of the heart muscle preparation must be much higher than for cytochrome *c* and cyanide must be omitted from the reaction mixture, since in its presence reduction is incomplete. Considering that these hæmoproteins do not react with cyanide, as will be shown later, it is possible that a factor sensitive to cyanide, present in a small amount in the heart muscle preparation, is involved in the respiratory chain linking the dehydrogenase systems with these hæmoproteins. The reduction of helicorubin and cytochrome *h* by these systems, like that of cytochrome *c*, is inhibited by

urethane and antimycin A. The oxidation of helicorubin and cytochrome *h* by the cytochrome oxidase system of a cytochrome *c*-deficient heart-muscle preparation[12] was studied manometrically and spectroscopically using ascorbic acid as hydrogen donor. These experiments showed that the addition of exogenous cytochrome *c* is essential for the oxidation of helicorubin and cytochrome *h* by cytochrome oxidase, and the reaction was found to be inhibited by cyanide and azide. The oxidation of reduced helicorubin and cytochrome *h* by oxidized cytochrome *c* can be observed spectroscopically in clear solutions of these hæmoproteins.

Accessibility of Hæmatin Iron to Ligands

Since helicorubin and cytochrome *h*, like cytochrome *c*, are naturally occurring hæmochromogen compounds, in each the iron atom of the prosthetic group is linked in positions 5 and 6 with two nitrogenous groups of the protein, one on each side of the flat molecule of the hæmatin (Fe^{3+}) or hæm (Fe^{2+}). The hæmatin or hæm prosthetic group of these hæmoproteins must therefore lie within a fold of the corresponding protein.

It has been shown that oxidized cytochrome *c* in solution combines reversibly with cyanide[13] and nitric oxide[14] within the physiological range of *p*H. Under similar conditions, reduced cytochrome *c* is not autoxidizable and combines neither with carbon monoxide nor with cyanide. Only below *p*H 4 or above *p*H 13 does it become autoxidizable and combine with carbon monoxide[14–16], while at *p*H 13 it forms a compound with cyanide[16]. This shows that the divalent iron of cytochrome *c* becomes accessible to ligands only when the bonds uniting its iron atom to the protein, and probably also some of the bonds linking the peptide chains within the protein folds, are loosened by treatment with acid or alkali. This process appears to be reversible provided the treatment is not too prolonged.

Oxidized helicorubin and cytochrome *h* do not combine with ligands such as cyanide and nitric oxide within the physiological range of *p*H. Outside this range, only the formation of a nitric oxide compound was followed spectroscopically and the reaction was found to take place at *p*H 2–3.

Reduced helicorubin and cytochrome *h* failed to react with carbon monoxide and cyanide even on standing in *N* sodium hydroxide solution for several hours; but when these hæmoproteins were treated with acids at *p*H 2 or 1·6 and then neutralized or made alkaline, they were found to combine with carbon monoxide and cyanide, forming compounds with characteristic absorption spectra. The absorption bands of these helicorubin compounds lie in the same positions as those of the same compounds obtained from protohæm, whereas the absorption bands of the corresponding derivatives of cytochrome *h* lie 2 or 3 mμ nearer the blue end of the spectrum. It is important to note that the above treatment, which makes the iron of these hæmoproteins accessible to carbon monoxide, cyanide and nitric oxide, causes irreversible denaturation of their proteins.

Properties of Helicorubin and Cytochrome *h* compared with those of Cytochrome *c*

Helicorubin and cytochrome *h* have several properties in common with a typical cytochrome *c* such as that isolated from baker's yeast or from horse heart muscle. These are: (1) a low molecular weight; (2) thermostability; (3) stability within a very wide range of *p*H (3–14); (4) the inaccessibility of their divalent iron to ligands; (5) the inhibition by antimycin A of their reduction by a heart muscle preparation containing sodium succinate or reduced diphosphopyridine nucleotide; and (6) the inhibition by cyanide of their oxidation by the cytochrome oxidase system.

They differ from cytochrome *c* in the following respects:

(1) In the reduced state their absorption spectra bear a greater resemblance to that of cytochrome *b* than to that of cytochrome *c*.

(2) Their isoelectric points lie below *p*H 4·3, whereas in cytochrome *c* it is above *p*H 10. In this respect they resemble some of the acidic cytochromes of the *c* group which have been isolated from bacteria[17,18].

(3) Their iron, both in the divalent and tervalent states, is less accessible to ligands (CO, CN′ and NO) than that of cytochrome *c*.

(4) Their oxido-reduction potentials lie about 66 mV. below that of cytochrome *c*.

(5) They are not autoxidizable in alkaline solutions (even in 2 *N* sodium hydroxide), but on the acid side autoxidation begins at *p*H 6, whereas cytochrome *c* only becomes autoxidizable below *p*H 4 and above *p*H 12.

(6) The prosthetic groups of helicorubin and cytochrome *h*, unlike that of cytochrome *c*, can be separated from their respective proteins by acid acetone, giving clear solutions of ether-soluble acid hæmatins. But whereas in helicorubin the prosthetic group is indistinguishable from protohæmatin, in cytochrome *h* it is a somewhat modified protohæmatin in which one of the vinyl groups is probably replaced by a saturated side-chain.

(7) The fact that the autoxidation of helicorubin and cytochrome *h* occurs at a *p*H when their iron is still inaccessible to ligands suggests that the autoxidation does not necessarily imply a direct reaction between the divalent iron and oxygen, but may be brought about in the same way as the oxidation of these hæmoproteins by ferricyanide or by oxidized cytochrome *c*.

This work has been carried out while in receipt of research grants from the Agricultural Research Council and the Wellcome Trust.

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LETTERS TO THE EDITORS

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Theories of Crystal Elasticity

From the time of the publication of the "Lehrbuch der Kristallphysik"[1] until 1951 there was no challenge to the classical theory of the elastic properties of crystals. At the Solvay Conference of that year, Laval[2] published an account of a theory which rejected some of the fundamental assumptions made in classical theory. Further work leading to the same conclusions was published later by Le Corre[3], Viswanathan[4], Raman[5] and Krishnamurti[6]. In non-mathematical language the difference between the old and new theories may be expressed as follows. On the classical theory, the equilibrium of a cube within a body at rest, which is subjected to any given set of mechanical stresses, is maintained solely by the forces acting normally or tangentially to its surfaces. If one edge of the cube is supposed vertical then tangential forces act on the vertical faces and, in equilibrium, the couples due to the tangential shear stresses acting on these faces just balance. The new theory denies the adequacy of this statement and asserts that 'volume-couples' can exist which must be balanced by the difference between the couples which were assumed to be equal and opposite in the old theory. In more formal language, the old theory asserts that the stress tensor is symmetric while the new theory asserts that it is in general non-symmetric. A corresponding difference exists in the treatment of the deformation experienced by the cube. The old theory assumes that all net rotations of the whole body may be regarded as irrelevant, so far as its elastic deformation is concerned. The new theory denies this and asserts that the deformation can only be adequately described by taking into account any net rotation which may be caused by the stresses. More formally, the old theory assumes a symmetric and the new theory a non-symmetric tensor for the strain. One of the consequences of the new theory is that the number of elastic constants is increased, for example, in the triclinic system from twenty-one on Voigt's theory to forty-five on the new theory.

To illustrate how volume couples can arise, a working model has been constructed which is in fact a model of one unit cell of the hexagonal form of selenium (Fig. 1). The four vertical rods have a triangular cross-section and are twisted about their lengths. Plates with a triangular hole fit over these rods and are separated by springs. (In Fig. 1 only one vertical rod is shown with its springs in place.) To each plate is attached a short horizontal rod in the appropriate direction, and a ball representing a selenium atom is supported by this rod. The whole unit cell can be compressed in a vertical direction by means of a frame. When this is done, the balls rotate about the vertical rods by an amount proportional to their distance above the base. How far can this model represent the state of affairs in the actual crystal ?

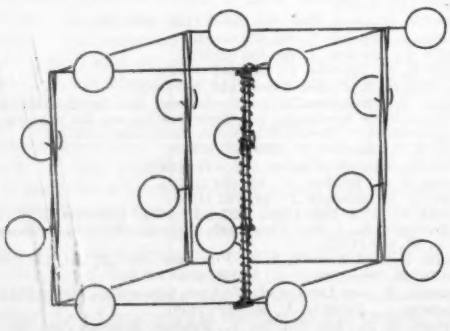

Fig. 1

The shortest bonds between selenium atoms form spiral chains parallel to the *c*-axis. The bonds between atoms in neighbouring spirals are longer and hence weaker than those within a given spiral. It is, therefore, not inconsistent with the symmetry, or with the arrangement of the atoms, for them to move in the manner indicated by the model. If such a rotation of the spiral chains tended to occur it would be resisted by the forces acting between the atoms in neighbouring spirals. In this way each spiral would be the origin of a couple and all these couples taken together would form a volume-couple of the kind assumed in the new theory.

If the spiral nature of the atomic distribution is responsible for the breakdown of the classical assumptions, then it is possible to establish in what classes of symmetry new effects might be observed. A centre of symmetry necessitates the presence of parallel spirals of opposite bands, and therefore it would not be expected that any centro-symmetric class would require the new theory. A plane of symmetry also converts a right-handed into a left-handed spiral but, except when the plane is parallel or perpendicular to the axis of the spiral, the rotatory effects are not mutually destructive. Thus, in addition to the eleven classes having only axes of symmetry, there are certain others, namely, m, mm, $\bar{4}$ and $\bar{4}2m$, in which the symmetry elements produce not more than two non-parallel groups of spirals of opposite hands. In these fifteen classes the new theory could apply if the spiral atomic arrangements are the determining cause. As an example of a crystal of class $\bar{4}2m$, ammonium dihydrogen phosphate ($(NH_4)H_2PO_4$) may be quoted. The structure of this crystal has PO_4 tetrahedra linked by hydrogen atoms in such a way as to build up spirals of atomic bonds —O—P—O—H—O—P—O—H—O— running parallel to the two-fold axes.

Experimental tests of the new theory have been carried out in two ways. Crystals of ammonium dihydrogen phosphate, when subjected to supersonic vibration and examined in a beam of light parallel to the *a*-axis, give a Bergmann–Schaefer diffraction pattern which shows that the mechanical transverse wave having a vibration direction lying in the *bc*-plane has a different velocity according to whether it vibrates along *b* or along *c*. The difference[3] is 17 per cent and far exceeds the experimental error. According to the old theory these velocities should be the same. Quartz crystals[7] examined by the same technique also afford support for the new theory. Another test is afforded by the piezoelectricity of quartz. According to the old theory (and the classical experiments) no charge can be liberated on the basal plane by any application of stress. Le Corre[3] has shown that when a torque is applied about the optic axis, a charge is developed on the plane perpendicular to that axis. All the above experiments which have

supported the new theory refer to crystals belonging to the classes of symmetry already mentioned.

Thus we believe that the classical theory of crystal elasticity is not applicable to crystals of all classes of symmetry and that some new theory would be applicable to the eleven enantiomorphous classes and also to classes m, mm, $\bar{4}$ and $\bar{4}2m$.

One of us (N. J.) gratefully acknowledges his indebtedness to the British Council for a research scholarship.

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Direct Structure Determination by Optical-Transform Methods

The optical-transform methods[1] for solving crystal structures are obviously of greatest use in dealing with chemical molecules the main outlines of which are known. It is interesting, however, to see whether they might be used for determining a crystal structure directly without any chemical information other than that of the unit-cell contents.

The following is a brief account of a structure investigated in this way; it is a simple example chosen specifically because it seemed to provide reasonable conditions for the operation of optical methods.

The substance crystallizes in the space group $P2_12_12_1$; the unit cell has dimensions $a = 17{\cdot}11$, $b = 3{\cdot}80$ and $c = 10{\cdot}67$ A. and contains four molecules of $C_7O_3NH_7$. The work to be described has been carried out entirely on the (01.) projection, which belongs to the plane group *pgg*.

The $h0l$ section of the weighted reciprocal lattice is reproduced in Fig. 1; it shows pronounced groups of strong reflexions at about 0·8 A.$^{-1}$ from the origin, arranged in a way that indicates the existence in the structure of a group of atoms similar to a benzene ring, the orientation and size of which can readily be deduced[1]. In addition, it shows a rectangular arrangement of strong reflexions about the origin which is long in the direction of a^*, and therefore implies a molecule which is long in a direction parallel to c.

To find the positions of the four rings in the unit cell, Taylor's[2] method was applied to those reflexions that lay on the strong parts of the transform of the single ring but which were, nevertheless, of small or zero intensity. An optical transform of the arrangement thus found was prepared and indicated reasonable agreement over much of the weighted reciprocal lattice section.

Signs were determined optically[3], and a Fourier synthesis calculated. This showed, of course, the ring which had been postulated, but, in addition,

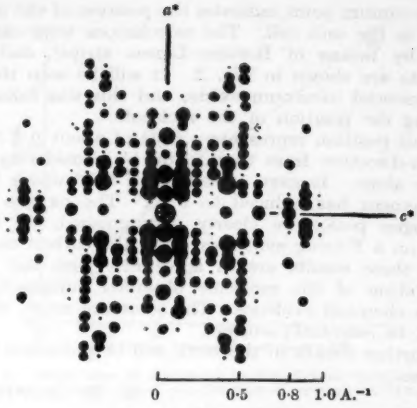

Fig. 1. The $h0l$ section of the weighted reciprocal lattice

several smaller peaks appeared. These were assumed to give possible positions of some of the remaining five atoms. Of a number of possibilities tested optically, the one which gave best agreement was taken as a basis for a further sign determination and Fourier synthesis. The choice of possible arrangements was also guided by the information that the molecule was long in the direction parallel to c. Continuation of these processes led to a molecule of eleven atoms, but the agreement residual for it could not be reduced to less than 0·45. It appeared, then, that Taylor's method, when applied to only about half the molecule, did not give reliable results. Nevertheless, it was hoped that the molecule found was substantially correct, and that application to the complete molecule would be more successful. One important difficulty in this problem is that the four rings in the projection are nearly parallel and thus add a pseudo mirror-plane which reduces the chance of obtaining a solution by the method.

To overcome this difficulty, a more quantitative form of the method has been devised. It is based upon the principle of the structure-factor graph[4]. A map of a function representing the combined discrepancies between observed and calculated intensities for a few chosen reflexions is prepared;

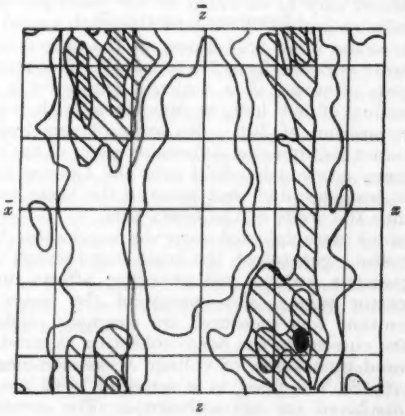

Fig. 2. Graph giving the position of the molecule in the unit cell, which is denoted by the small black region

its minimum point indicates the position of the molecule in the unit cell. The calculations were carried out by means of Beevers–Lipson strips[5], and the results are shown in Fig. 2. It will be seen that a pronounced minimum exists, and this was taken as giving the position of the molecule.

This position represents a shift of about 0·5 A. in the z-direction from that found by considering the rings alone. It gave a residual of 0·30 which later refinement has reduced to 0·15. The oxygen and nitrogen peaks are clearly distinguished, by their size on a Fourier synthesis, from the carbon atoms, and these results are in agreement with the configuration of the molecule obtained independently from chemical evidence. The structure must, therefore, be essentially correct.

Further details of the work will be published elsewhere.

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[2] Taylor, C. A., *Acta Cryst.*, **7**, 757 (1954).
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An Experimental Proton Linear Accelerator using a Helical Waveguide

A previous communication[1] proposed the use of a helical slow-wave structure to accelerate protons up to 20 MeV. An experimental section of this type of accelerator has now been constructed at this Laboratory.

The helix structure consisted of a wire helix wound on a glass tube which was evacuated to allow the proton beam to pass along the axis. Outside the tube a pressure of 150 lb./sq. in. was maintained to prevent radio-frequency breakdown between turns of the helix and to assist in cooling. Cooling is important, since in some circumstances the mean dissipation may be as much as 600 watts per metre. The helix radius was 1 cm. and the pitch varied from 4 mm. at the input to 4·6 mm. at the output end to accelerate particles from 2·5 to 4 MeV. This acceleration was obtained in a 1-metre length for a peak power flux of 500 kW. at 300 Mc./s. with a phase stable position of 30°. No attempt was made to counteract the inherent defocusing effect of the radio-frequency accelerating field over the 1-metre length, and it was accepted that some of the beam may be lost into the walls of the beam tube.

Protons were injected into the accelerator by an electrostatic generator[2], the beam being pulsed before injection to reduce wall-charging effects in the accelerator tube. The energy of the beam after acceleration was measured by magnetic deflexion, and the current to the beam-collecting electrode was measured by the rise of voltage across the electrode capacitance, amplified in a screened head amplifier and displayed on an oscilloscope. The accelerator was operated under travelling-wave conditions without external feedback, the full 500 kW. of radio-frequency power at 300 Mc./s. being provided by an oscillator specifically designed for this purpose. The oscillator was driven from a radar modulator modified to give a 6-μsec. pulse. The high-frequency power at the input and output of the helix was monitored, providing a constant check on the transmission losses.

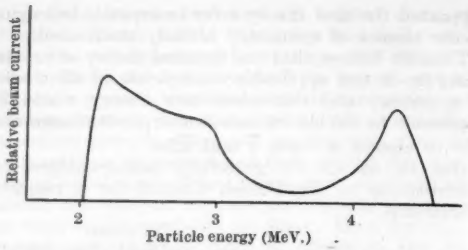

Fig. 1. Energy spectrum for 500-kW. radio-frequency power flux and 2·5-MeV. injection energy

The measurements which are of primary interest are the energy spectrum under optimum conditions, and the relative magnitude of the accelerated beam. Fig. 1 shows the energy spectrum for the design values of power flux and beam energy input, which proved to be near optimum. The curve represents the average of a large number of readings necessitated by fluctuations of beam current, presumably arising from wall-charging inside the tube supporting the helix. The peak in the spectrum at 4·3 MeV. was higher than expected from the design figures, but cold measurements of phase velocity indicated a final velocity corresponding to nearly 4·3 MeV. The spread of energy at the accelerated peak was consistent with the theoretically predicted value of ± 5 per cent, and magnetic analyser resolution of 0·2 MeV. The beam current in the range 4·3 MeV. ± 5 per cent represented 20 per cent of the total current in the spectrum. This result compares reasonably with the design value of 25 per cent for a 90° acceptance angle, which suggests that only a small proportion of the beam is lost by defocusing, even though a large (5 mm. diameter) beam was used. The total current in the spectrum, however, represents only 15 per cent of the input beam current, and it is thought that this loss of current is due to deflexion of the beam by charges on the glass walls of the tube supporting the helix.

The results so far obtained with the helix accelerator indicate that it functions in principle in accordance with design. To increase the relative accelerated beam current, however, it would be necessary to surmount the problem of preventing wall-charging and, for a higher-energy accelerator, preventing defocusing.

We wish to thank Mr. R. Bailey for his part in this work and Dr. T. E. Allibone for permission to publish this communication.

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[1] Chick, D. R., and Petrie, D. P. R., *Nature*, **168**, 782 (1951).
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Diurnal Variation in the Occurrence of 'Dawn Chorus'

In the audio-frequency range, a phenomenon called 'dawn chorus', which is characterized by a multitude of rising tones, is frequently observed. Other investigators[1,2] have noted that this phenomenon exhibits a pronounced diurnal variation of intensity, with the maximum occurring during the early morning hours, and the name 'dawn chorus' has been derived on this basis. The observations of 'dawn chorus' reported here were made between January 1 and July 2, 1956, at College, Alaska, with equipment sensitive to frequencies between 1 to 10 kc./s. During this interval, the equipment was in operation on 116 days. 'Dawn chorus' was found to be present in 224 of the 2,784 one-minute hourly observing periods. The diurnal variation in the frequency of occurrence of 'dawn chorus' is illustrated in Fig. 1, which represents a histogram of the number of times 'dawn chorus' was found to be present during the one-minute recording interval for each of the twenty-four hours of the day.

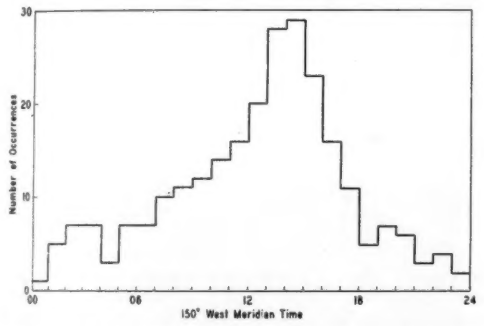

Fig. 1. Diurnal variation in the occurrence of 'dawn chorus' at College, Alaska

The main feature shown by the histogram is that the time of maximum occurrence of 'dawn chorus' at College is at 1400 hr. local time, in contrast to the morning hour maximum noted by other observers. Since College is situated in a high geomagnetic latitude whereas the earlier observations were made at lower latitudes, one is led to inquire if the difference in the local time of maximum varies systematically with latitude. In order to test this hypothesis, the observations of 'dawn chorus' at College for the first half of the year 1956 have been compared with those obtained during the same period at four other stations. The local times of the daily maximum in the occurrence of 'dawn chorus' for the five stations are listed in Table 1 and plotted against geomagnetic latitude in Fig. 2. A straight line has been fitted to the points of that figure. Storey[1] gives 0600 as the time of maximum for Cambridge (geomagnetic latitude 55°N.),

Table 1

Station	Symbol	Geomagnetic latitude	Local time of maximum	Mean local magnetic noon
College, Alaska	*CO*	65° N	1400	1350
Hanover, New Hampshire	*HA*	55° N	0700	1200
Washington, D.C.	*WA*	50° N	0500	1215
Wellington, New Zealand	*WE*	45° S	0200	1115
Dunedin, New Zealand	*DU*	50° S	0430	1120

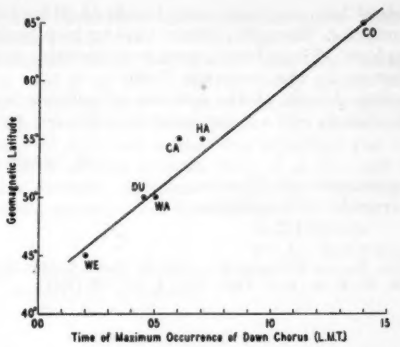

Fig. 2. Local time of maximum in the diurnal variation of occurrence of 'dawn chorus' as a function of geomagnetic latitude

and the corresponding point (*CA*) has been included in Fig. 2 for comparison.

Although the number of points is limited, the observations nevertheless suggest that the time of the diurnal maximum in the occurrence of 'dawn chorus' is related to geomagnetic latitude.

In view of the fact that the daily maximum of 'dawn chorus' does not, in general, occur at dawn, it is suggested that it be referred to simply as 'chorus'.

The observations from the stations in New Zealand and the United States were obtained by interchange, and I wish to acknowledge the co-operation of Drs. G. M. Allcock, H. E. Dinger, L. H. Martin and M. G. Morgan. I am also indebted to Dr. L. Owren for assistance in the preparation of the manuscript. The work reported here was supported by the U.S. Air Force Cambridge Research Center, under contract No. *AF* 19(604)–1859.

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June 14.

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[2] Allcock, G. McK., and Martin, L. H., *Nature*, **178**, 937 (1956).

Band Spectrum of Gallium Hydride and Gallium Deuteride

I have observed and measured some faint absorption bands in the spectra of gallium hydride and deuteride. The bands are composed of single *P*, *R* and *Q* branches belonging to a $(\Pi - \Sigma)$ electron transition. The branches are degraded to the violet, and consist of sharp and wide-spaced lines.

The spectrograms were taken with a high resolving power immersion spectrograph[1]. A quartz tube with an effective absorption length of 120 cm. was used as the absorption cell. The tube was heated by means of an electric furnace to a temperature of about 1,200° C., the pressure of hydrogen and deuterium being 1 atm. The following constants were calculated for (0–0) bands:

Gallium hydride		Gallium deuteride	
ν_0	= 17,626·84 cm.$^{-1}$	ν_0	= 17,634·36 cm.$^{-1}$
B_e''	= 6·046 cm.$^{-1}$	B_e''	= 3·083 cm.$^{-1}$
B_{ad}'	= 6·518 cm.$^{-1}$	B_{ad}'	= 3·337 cm.$^{-1}$
B_{ac}'	= 6·526 cm.$^{-1}$	B_{ac}'	= 3·340 cm.$^{-1}$
D_e''	= -356×10^{-4} cm.$^{-1}$	D_e''	= -84×10^{-4} cm.$^{-1}$
D_{ad}'	= -449×10^{-4} cm.$^{-1}$	D_{ad}'	= -109×10^{-4} cm.$^{-1}$
D_{ac}'	= -468×10^{-4} cm.$^{-1}$	D_{ac}'	= -116×10^{-4} cm.$^{-1}$

Garton[2] has observed some bands at 2160–2400 A. in absorption through gallium vapour in a hydrogen atmosphere. These bands were provisionally ascribed by Garton to the molecule GaH.

Further details of the spectra of gallium hydride and deuteride will appear later in *Arkiv för Fysik*.

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[1] Hulthèn, E., and Neuhaus, H., *Arkiv för Fysik*, **8**, 343 (1954).
[2] Garton, W. R. S., *Proc. Phys. Soc.*, A, **64**, 509 (1951).

Ultra-Violet Absorption Spectra of L-Asorbic Acid in Aqueous Solutions

In a previous communication[1], it was reported that D-sorbitol enhances the absorption in the ultra-violet by aqueous solutions of L-ascorbic acid. Continuing the work, it appeared that the 'enhanced' values are simply the true values of the ultra-violet absorption of L-ascorbic acid, which hitherto have been measured only occasionally and unsystematically.

As will be seen from Table 1, the values of E(1 per cent, 1 cm.) given in the literature are around 550, with some notable exceptions. Some of the values reported were obtained in the presence of potassium cyanide, which is known to prevent autoxidation of ascorbic acid. However, the highest values, given by Carpeni, were obtained without the addition of cyanide and in anaerobic conditions. The values given in my previous communication were 630 and 550 for the mono-dissociated and non-dissociated forms of L-ascorbic acid. In the presence of D-sorbitol, the respective values were 916 and 676. Pursuing the investigation, it was found that ethylenediamine-tetra-acetic acid (versene), like D-sorbitol, enhanced the ultra-violet absorption of L-ascorbic acid; this suggested that both substances could act by trapping copper or other metallic ions which have a catalytic effect on the autoxidation of the acid.

Table 1. Values of E(1 per cent, 1 cm.) found in the literature for the ultra-violet absorption bands of the non-dissociated (245 mμ) and the mono-dissociated (265 mμ) form of L-ascorbic acid in aqueous solutions

Author(s)	Year	Publication	265 mμ	245 mμ
R. W. Herbert *et al.*	1933	*J. Chem. Soc.*, 1280		543
A. Chevalier and Y. Charon	1937	*C.R. Soc. Biol.*, **124**, 453	540	
M. Mohler and H. Mohr	1938	*Helv. Chim. Acta*, **21**, 485	543	
G. E. Carpeni	1938	*Helv. Chim. Acta*, **21**, 1031	908	798
D. C. M. Adamson and N. Evers	1941	*Analyst*, **66**, 106	530	543
R. A. Morton	1942	"The Application of Absorption Spectra to the Study of Vitamins and Hormones" (London)	714	
C. S. Vestling and M. C. Rebstock	1945	*J. Biol. Chem.*, **161**, 288		471
H. R. Rosenberg	1945	"Chemistry and Physiology of the Vitamins" (New York)	543	
M. H. Hack	1947	*Biochem. J.*, **41**, 523	400	688
K. H. Coward	1947	"Biological Standardization of the Vitamins" (London)		568
	1948	*British Pharmacopœia*		550
	1951	*Pharmacopœia Internationalis*		550
C. Daglish	1951	*Biochem. J.*, **49**, 636	860	525
K. Heyns and H. Paulsen	1953	*Ber.*, **88**, 836	450	450
D. C. Garratt	1955	"Quantitative Analysis of Drugs" (London)		560
J. S. Lawendel	1956	*Nature*, **178**, 873	630	550
J. S. Lawendel	1957	Present communication	945	695

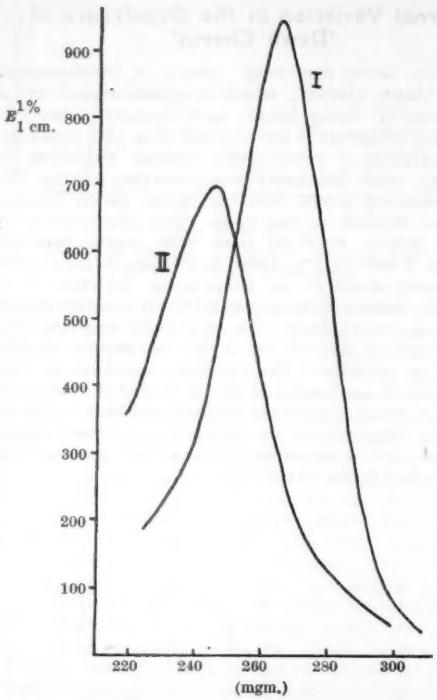

Fig. 1. Ultra-violet absorption of L-ascorbic acid (I) at *p*H 6·4; (II) at *p*H 2·0

It was finally found that by working with the purest ascorbic acid, glass-distilled water and complete anaerobiosis (removal of traces of oxygen by bubbling oxygen-free nitrogen through the water before the addition of L-ascorbic acid) the following values were obtained: E(1 per cent, 1 cm.), for the non-dissociated form at 245 mμ (*p*H 2, with dilute hydrochloric acid), 695; for the mono-dissociated form at 265 mμ (*p*H 6·4, with phosphate buffer), 940. These values are higher than those given in the literature, except for the value (798) given by Carpeni for the non-dissociated form of L-ascorbic acid. I was unable to obtain so high a figure.

My results were obtained with final concentrations ranging from 0·5 to 1 mol. $\times 10^{-4}$. For the lower concentrations, only by the use of strict anaerobic conditions can the values be prevented from decreasing. I believe that my present values are nearer the real ones than any hitherto reported. A warning may be given in connexion with the measurement of L-ascorbic acid absorption for analytical purposes: anaerobic conditions are essential when no stabilizers are used. When anaerobic conditions are difficult to maintain for technical reasons the use of appropriate stabilizers, and among them D-sorbitol as reported, is recommended.

Fig. 1 represents the ultra-violet absorption of aqueous solutions of L-ascorbic acid at acid and neutral *p*H values.

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[1] Lawendel, J. S., *Nature*, **178**, 873 (1956).

Hexagonal Chromium Crystals from Fused Electrolytes

THE meaning of the hexagonal structure sometimes observed in chromium electroplates has been the subject of considerable study. The present communication is to record some observations on chromium produced by electro-refining in fused-salt baths. The particular bath used in the production of the chromium described here consisted of sodium chloride, chromium chlorides, and dissolved metallic sodium at 800° C. The cathode deposit consisted of a layer of fine crystals in salt and coarse idiomorphic chromium crystals attached to them.

The coarse crystals were in the form of hexagonal plates and rods as shown in Fig. 1. Fig. 2 shows some of the rods bent to show their ductility. Both pictures are at about twice natural size. X-ray examination shows the plates to be body-centred cubic, so that they are pseudomorphs after the hexagonal form.

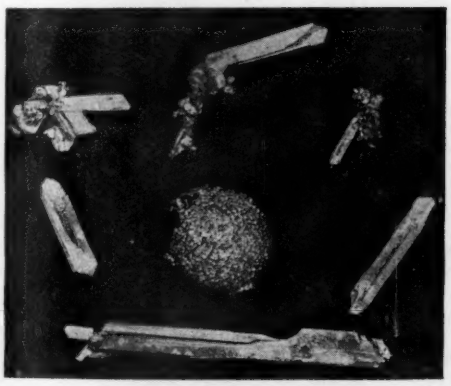

Fig. 1

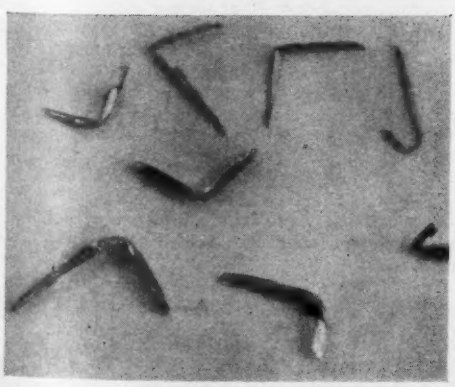

Fig. 2

We regard it as improbable that the hexagonal form is stable at 800° C., but think rather that it represents formation of an unstable modification under the particular conditions. The crystals have a density of 6·9, and a hardness of about 130 DPH.

The layer of fine crystals formed in the salt layer has the lowest electrical resistance reported for chromium, namely, 3·6 microhms/cm.

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A Performance Index for Gas Chromatographic Columns

J. Friend and E. Watson have suggested that if an adequate 'performance index' could be defined for gas chromatographic columns, a much-needed clarification could be achieved in the interchange of data among experimenters.

A theoretical study of gas chromatographic columns has indicated that the following expression is reasonably invariant under a large range of conditions, and has other properties which commend it as a performance index :

$$\frac{\Delta t^4}{t^3\left(t - \frac{3}{4}t_a\right)} \cdot (t_a\,\Delta p)$$

where Δt is width of 'band' at mid-height; t_a is time interval between injection and centre of 'air peak'; t is time interval between injection and centre of band; and Δp is pressure drop across column; all times are in seconds, Δp in dynes cm.$^{-2}$.

The theoretical basis for the expression given above, the smallness of which constitutes the desirable property, is too lengthy to give here, but its several properties will be mentioned briefly.

(1) When the column is operated at the optimum flow-rate for band separations, the performance index constitutes a parameter depending essentially upon the packing material of the column; it is invariant with the column diameter and length, and to a large extent with the proportion of oil in the substrate of a gas–liquid partition column.

(2) If written as follows :

$$\text{Performance index} = \left(\frac{\Delta t}{t - t_a}\right)^4 \times \frac{(t - t_a)^4 t_a}{t^4\left(t - \frac{3}{4}t_a\right)} \cdot (t\,\Delta p)$$

the first term of the expression is proportional to the fourth power of the relative 'band width', which is analogous to the spectral slit-width of the spectroscopist, and inversely proportional to the resolving power; the second term is a maximum when $t = 4{\cdot}3\,t_a$, which indicates that, other things being equal, optimum separation of a given pair of components will occur when the capacity of the static phase for these components is a little more than three times the capacity of the mobile phase; and the third term may be considered as the 'price' paid for separation, in terms of the time of waiting required for the elution of the slowest component, and of the pressure drop across the column.

The spectrometrist who works in the far infra-red region and utilizes slit openings which are much

larger than the slit-width may note that the price paid for resolution in terms of time of waiting is the same in gas chromatography as in his field of spectrometry. On the other hand, the gas chromatographist has another quantity he can 'trade' for either speed, or resolution, namely, pressure differential across the column.

It should be emphasized that the trading of time and pressure for each other, or for resolution, must be done at the time the column is engineered. Once the column has been designed and installed in the gas chromatographic apparatus, the operating conditions are essentially determined. There is an optimum separation to be obtained for a given pressure-drop and in a given time, and pressure and time may be traded for each other within narrow limits only, without lowering the inherent resolution.

It should also be emphasized that the performance index is fairly characteristic of the column material and column geometry. It serves to guide the engineering of a column, but research is required to find new materials and geometries with the desired smaller performance indexes.

(3) The performance index has the dimension of viscosity in poises, and theoretical considerations indicate that in an ideal column it should be of the order of the carrier-gas viscosity times a large numerical constant; that is, it should be of the order of 0·1 poise. In practice, it has been found to be of the order of 1,000 poises for 'Celite' columns for a large range of oil impregnation, and for a variety of components separated. This very large ratio between the actual and ideal performance indexes constitutes a measure of how much room for improvement there is in basic column design.

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Micelle Dimension of Potato Starch

Native starches are, of course, polycrystalline materials, and their submicroscopic structure has been studied using X-ray diffraction procedures by many workers. Nevertheless, the fine structure of native starch granules is still unknown.

We have carried out X-ray diffractometric studies to obtain information on the micelle dimension of starch molecules in connexion with electron microscopic observations of ultra-thin sections of starch granules, which showed an arrangement of very fine micro-granules about 200 A. in diameter[1]. The micelle dimensions of cellulose have been measured in various ways, but for starches no exact experimental results have been reported.

The size of a crystallite of a polycrystalline material can be calculated from the broadening of the diffraction line using Scherrer's equation:

$$D_{(hkl)} = \frac{0{\cdot}9 \times \lambda}{\beta_{1/2} \times \cos\theta}$$

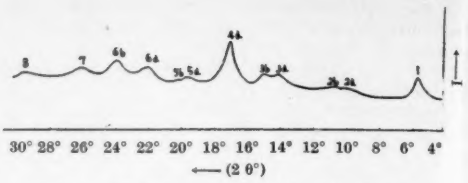

Fig. 1. Whole-line profile of wet potato starch

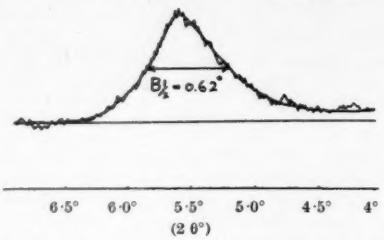

Fig. 2. Line profile of line 1 of wet potato starch

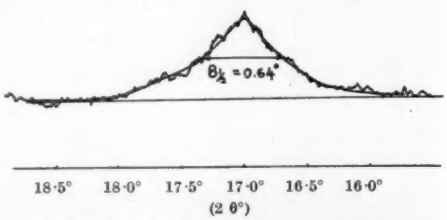

Fig. 3. Line profile of line 4a of wet potato starch

where $D_{(hkl)}$ is a mean dimension and λ, $\beta_{1/2}$ and θ represent the wave-length of X-ray used, the real half-maximum breadth and the Bragg angle respectively[2].

As regards the specimen, potato starch was prepared in the usual manner from potato tubers and stored in a refrigerator as an aqueous suspension. Before use, the suspension was sucked on to a glass filter, washed and the wet specimen was packed into an aluminium frame. A 'Norelco' X-ray diffractometer of the North American Philips Co. was used.

The experimental conditions for obtaining a whole-line profile were as follows: high-tension voltage, 30 kV.; current, 15 m.amp.; scale factor, 4; multiplier, 1; time constant, 8 sec.; divergence slit, 1°; receiving slit, 0·006 in.; scatter slit, 1°; scanning speed, ½° per min.; chart speed, ½ in. per min.; X-rays, nickel-filtered copper radiation.

Some factors were changed when detailed curves for line 1 and line 4a were examined; namely, scale factor, 2; time constant, 16 sec.; divergence slit, ¼°; scatter slit, ¼°; scanning speed, ¼° per min.; chart speed, ¼ in. per min.

A whole-line profile of wet potato starch is shown as Fig. 1. The labelling of the peaks of the curve corresponds to Katz's nomenclature of his Debye–Scherrer rings, and their lattice constants are given in Table 1.

Table 1. Lattice Constants of Wet Potato Starch

Line	1	2a	2b	3a	3b	4a	5a	5b	6a	6b	7	8
d (in A.)	15·79	8·82	7·89	6·34	5·96	5·215	4·55	4·40	4·04	3·70	3·43	2·89

Figs. 2 and 3 represent detailed curves of line 1 and line 4*a*, respectively. Their observed half-maximum line-breadths ($B_{1/2}$), 0·62° and 0·64°, were corrected by Alexander's correction curve[3] and the quartz line (101).

Thus, the pure half-maximum breadths ($\beta_{1/2}$) were deduced as 0·54° for line 1 (100) and 0·56° for line 4*a* (020), and the micelle dimensions $D_{(hkl)}$ were calculated as follows:

$$D_{(100)} = 147 \text{ A.}, \quad D_{(020)} = 144 \text{ A.}$$

Thus, $D_{(100)}$ and $D_{(020)}$, that is, the average micelle dimensions for the *a* and *b* directions of Rundle's unit cell of potato starch[4], were estimated to be 147 A. and 144 A., respectively.

The average micelle-length in direction *b*, parallel to the long axis of the molecular chain, corresponds to the length of 28 glucose residues and agrees fairly well with the average end-chain-length of potato amylopectin[5] (27 glucose residues) and also with the average chain-length of potato amylo-dextrin[6] (25 glucose residues), which was prepared by cold acid treatment of raw potato starch and was believed to constitute the crystalline regions of the starch granules.

The average micelle dimension for the *c*-direction of Rundle's unit cell could not be obtained. But this value represents the micelle breadth perpendicular to the long axis of the molecular chain, and it might not be very large.

Therefore, the crystalline part of native wet potato starch may be considered to be a sphere or a bunch of about 145 A. in diameter.

We are grateful to Prof. I. Nitta and members of his laboratory for their valuable advice.

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Reaction of Globin with Hæmin in Interfacial Films

Recently, we reported[1] that Π, the maximum pressure of bovine globin in the *p*-xylene/water interface, was approximately twice as high as that of bovine oxyhæmoglobin, and that addition of hæmin lowered the high interfacial pressure of globin. This surprising phenomenon was investigated more thoroughly, as described below.

The interfacial tension was measured by the ring method as described earlier (ref. 1, p. 54). The lower layer was formed by 20 ml. of 0·06 *M*-glycine buffer *p*H 10, containing 0·05 per cent of native bovine globin prepared according to Anson and Mirsky[2]. Increasing amounts of a 0·1 per cent solution of protohæmin chloride in the same buffer solution were added to the globin solution and the interfacial tension measured after stirring the aqueous layer. In control experiments protohæmin was replaced by protoporphyrin, and globin by bovine γ-globulin (Armour).

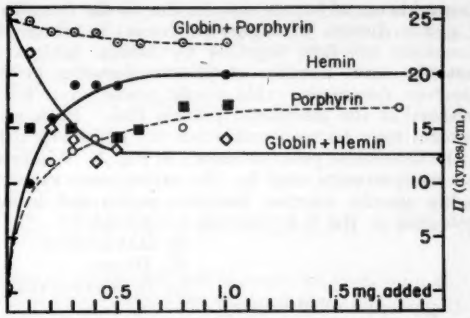

Fig. 1. The abscissa shows the amount of protohæmin or protoporphyrin added to the glycine buffer solution which formed the lower layer. The two ascending curves show the results obtained with protein-free buffer solution, the descending curves the results obtained with 10 mgm. of bovine globin. The black squares indicate values obtained on the addition of protohæmin to a buffer solution containing 10 mgm. of bovine γ-globulin

The interfacial tension γ_s was calculated from the maximum pull by means of the correction factors of Zuidema and Waters[3]. The maximum film pressure, Π, is obtained by deducting γ_s from γ_0, the interfacial tension of the system buffer solution/*p*-xylene (ref. 1, p. 54).

Fig. 1 demonstrates that the amount of hæmin required to lower the interfacial pressure of 10 mgm. of globin to its minimum is 4–5 per cent of the weight of the globin. This is very close to the percentage of hæm in hæmoglobin. Fig. 1 also shows that the globin–hæmin interaction is quite specific; the high interfacial pressure of globin is very little affected by the addition of protoporphyrin, nor is the interfacial pressure of bovine γ-globulin lowered by protohæmin. Fig. 1 also shows that the interfacial pressure increases considerably when hæmin or porphyrin is added to the protein-free buffer solution.

Results identical with those recorded in Fig. 1 were obtained when bovine globin was replaced by native globin of man, rat or rabbit. In all these species the maximum interfacial pressure of globin at *p*H 10 was 22–25 dynes/cm. Reduced hæmoglobin, produced by adding 1 mgm. of sodium dithionite to the aqueous layer, had the same interfacial pressure as the corresponding oxyhæmoglobin. Similar but smaller differences between globin and oxyhæmoglobin were observed in the system water/bromobenzene where the organic solvent forms the lower layer. In the air/water interface the differences in Π were only 2–3 dynes/cm.

Since the globins used in these experiments were native and able to form oxyhæmoglobin on addition of hæm, we hoped to gain some insight into the mechanism of hæm–globin interaction. However, identical results were obtained when the solutions of native globin were replaced by solutions of denatured globin. Most probably, native globin undergoes denaturation when it is spread in the water/xylene interface; it is well known that hæmin combines specifically with denatured globin to form 'globin-hæmochromogen'[4].

The interpretation of the specific drop in the interfacial pressure of globin on addition of hæmin is not quite clear. Earlier[1] we attributed it to the combination of the hæmin molecules with non-polar groups of the globin molecules and concomitant decrease in the affinity of globin to the *p*-xylene layer. Alternately, the drop in the interfacial pressure of globin

after addition of hæmin may be due to the formation of globin dimers (or higher polymers) in which the monomers are held together by hæmin bridges so that the total number of protein particles in the interface decreases; this would result in a lower pressure of the interfacial protein film. Both phenomena may be responsible for the enormous drop in the interfacial pressure shown in Fig. 1. Whatever the interpretation may be, the experiments reveal a highly specific reaction between globin and hæmin molecules in the *p*-xylene/water interface.

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Cholinesterase Content of the Dog's Lymphocytes and Polynuclears

I have already indicated the presence of cholinesterase in dog's, rabbit's and man's white blood cells[1]. The cholinesterase of the leucocytes is similar to that of the erythrocytes. A technique I have recently described[2] was used for the separation of the various morphological forms of white cells. Since then I have studied the cholinesterase content of dog lymphocytes and polynuclears separately (see Table 1). Determination of the enzyme was based on Michel's method[3].

Table 1. Cholinesterase Content of Dog's Polynuclears and Lymphocytes expressed in ΔpH/hr. The Values are the Average of Eight Experiments

Polynuclears (per mm.)	Polynuclear solution (ml.)	Lymphocytes (per mm.)	Lymphocyte solution (ml.)	Polynuclear cholinesterase	Lymphocyte cholinesterase
8,300	2	4,600	8·1	0·825	0·500

The cholinesterase activity is inhibited by a high concentration (0·06 gm.) of the substrate acetylcholine, whereas it is high at the lower (0·004 gm.) concentration (Table 2). It is therefore suggested that the enzyme may be one of the specific cholinesterases. This type of enzyme is found in both forms studied.

Table 2. Cholinesterase Content of Dog's Polynuclears and Lymphocytes in Δ pH/hr. Note Greater Values at 0·004 gm. Substrate Concentration. The Values are the Average of Three Experiments

Polynuclears (per mm.)	Polynuclear solution (ml.)	Lymphocytes (per mm.)	Lymphocyte solution (ml.)	Polynuclear cholinesterase (0·004)	Polynuclear cholinesterase (0·06)	Lymphocyte cholinesterase (0·004)	Lymphocyte cholinesterase (0·06)
13,800	7	8,800	20·1	1·063	0·246	1·300	0·386

Further work on these lines is being undertaken; details of the results will be published elsewhere.

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Effects of Carbon Sources and Base Analogues of Nucleic Acid on the Formation of Bacterial Amylase

A washed suspension of *Bacillus amyloliquefaciens* Fukumoto cells[1], which is a strain of *Bacillus subtilis* that has been used for the industrial production of bacterial α-amylase, secretes a small but distinct amount of amylase when shaken aerobically in the presence of phosphate. Under the same conditions, the addition of a sugar or a salt of an organic acid as the carbon source causes a great increase in the formation of amylase without any addition of nitrogen source[2]. Since the enzyme detected in the autolysate or lysozyme-lysed solution of the bacterial cells is very small, it seems to be certain that the amylase appearing in the cell suspension did not pre-exist in the bacterial cells, but is newly formed and secreted by the cells. In this experiment, however, the amount of enzyme formed differs markedly according to the type of carbon source[3]. As seen in Table 1, there

Table 1. Amylase Formation and Respiration of the Cell Suspension on Various Kinds of Carbon Sources

46 mgm. of cells as dry matter, *M*/10 phosphate, 0·5 per cent sugar or *M*/30 organic acid (sodium salt); total vol., 15 ml.; *p*H 6·8, 10 hr.

Carbon sources	Amylase activity per ml.*	Q_{O_2}†	Carbon sources	Amylase activity per ml.*	Q_{O_2}†
None	4·0	16	Mannose	5·3	65
Pyruvate	15·0	91	Galactose	21·5	56
Gluconate	15·5	55	Maltose	13·5	81
Xylose	2·7	15	Sucrose	4·0	82
Arabinose	19·5	62	Lactose	24·0	56
Ribose	20·5	67	Soluble starch	17·5	71
Glucose	3·8	92	Mannitol	15·5	—

* The activity of 1 μgm. of crystaline bacterial amylase is taken as one unit (ref. 4).
† Determined after 2 hr. shaking.

is no clear adaptive relationship between the formation of enzyme and the carbon sources, and also the amount of amylase formed is not in any way parallel to the respiration activity of the cell, which is related to the carbon sources. This characteristic effect of carbon source on enzyme formation is almost always observed, regardless of the type of carbon source on which the cells are grown. Sugars such as glucose and fructose are not only ineffective but may be even somewhat inhibitory, and adding them to other carbon sources which are available for enzyme formation completely nullifies their effect. This diauxic effect[4] appears almost immediately after the addition of these sugars, and remains constant during the course of the experiment, although no metabolic product inhibitory to enzyme formation has yet been detected in the cell suspension system. However, even on a glucose carbon source, good formation of the enzyme occurs to the same extent as from a galactose carbon source, if the glucose concentration is maintained at a very low level (about 0·01–0·02 per cent).

Considering these divergent effects of carbon sources on enzyme formation, the following facts seem to be very suggestive. The cells under the experimental conditions indicated in Table 1 secrete

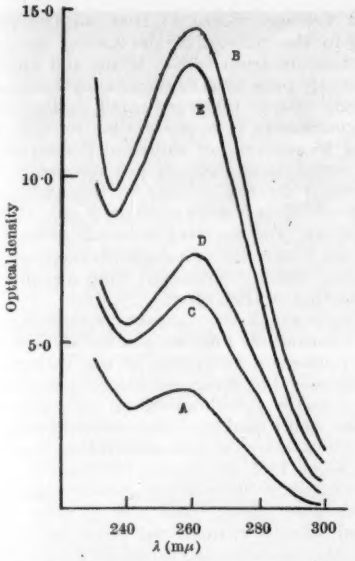

Fig. 1. Ultra-violet absorption spectra of the filtrate of the cell suspension (conditions as in Table 1). *A*, without sugar; *B*, glucose; *C*, galactose; *D*, lactose; *E*, *D* + chloramphenicol (20 μgm. per ml.)

several kinds of nucleic acid-bases in a free state, varying in amount with the type of carbon source (Fig. 1). In the presence of glucose (0·5 per cent) the amount is remarkably large, most of it having been identified as uracil. It has been also observed that the formation of amylase in the cell suspension is inhibited by addition of thiouracil or 8-azaguanine, and that the degree of inhibition is dependent on the type of carbon source used in the experiment (Table 2). Severe inhibition is found with carbon sources with which the cells secrete more nucleic acid-bases, and much less inhibition occurs where the cells secrete less nucleic acid-bases. However, with the cell suspension system supplied by a certain nitrogen source, almost complete inhibition occurs upon addition of the base analogue, regardless of the type of carbon source (Fig. 2).

In the cultivation of the bacteria, the amylase activity of the culture filtrate is found to increase most rapidly at the beginning of the stationary

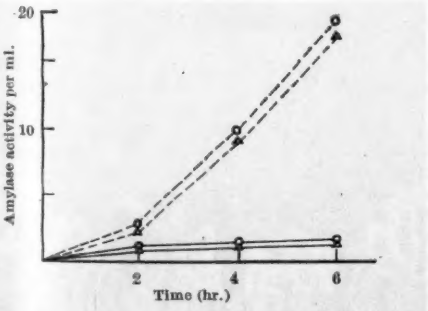

Fig. 2. Effect of 8-azaguanine on amylase formation in the presence of polypeptone (41 mgm. of cells as dry matter, 0·3 per cent polypeptone; the other conditions were the same as Table 1). —O—, galactose; —△—, glucose; ———, with *M*/500 8-azaguanine; - - -, without 8-azaguanine

Table 2. Effect of 8-Azaguanine on Amylase Formation

68 mgm. of cells as dry matter, *M*/600 8-azaguanine; the other conditions were the same as Table 1

Carbon sources	None		Pyruvate		Glucose		Galactose		Maltose		Lactose	
Addition of 8-azaguanine	−	+	−	+	−	+	−	+	−	+	−	+
Amylase activity, per ml.												
2 hr.	6·0	4·8	7·0	3·0	4·5	0·9	9·0	6·8	6·0	1·6	8·5	5·0
4 hr.	8·0	5·0	11·0	5·0	6·4	1·0	15·2	13·0	10·0	1·7	14·5	10·5
6 hr.	9·5	7·0	14·5	7·5	9·3	1·1	18·5	15·0	13·0	2·1	18·0	11·5

phase of cell growth and to reach its maximum at the period immediately before autolysis of the cells. This might lead to the phenomenon reported by Nomura and his co-workers[8], using a certain strain of *Bacillus subtilis*, that bacterial α-amylase formation and cell growth are inversely related. With aerobic shaking of the cell suspension of our bacteria, without addition of any substance, no enzyme is produced; but there is a good formation of spores together with great consumption of cell protein. In the presence of sugar without phosphate, or in the presence of both phosphate and a sugar which is unsuitable for amylase formation, very little enzyme is formed and good spore formation does not occur; but there is secretion of certain kinds of proteins other than amylase, in a considerable amount. On the other hand, under conditions suitable for amylase formation, the amount of nitrogen substances secreted from the cells is relatively small, although the cells show moderate respiration. From the experimental results described above, amylase formation by the cells is greatly influenced by the type and concentration of carbon source added to the cells. This appears to be true, to some extent, in the formation of some other enzymes of the bacterial cells. It is well known that a vigorous protein metabolism always accompanies a vigorous nucleic acid metabolism. The results shown in Table 2 and Fig. 2, however, seem to indicate that the more severe the inhibition of amylase formation by 8-azaguanine, the more vigorous was the original synthesis of nucleic acid taking place in the cells. This leads to the assumption that nucleic acid metabolism of the cells is also greatly influenced by the type of carbon source, especially in the absence of nitrogen source, as seen in Table 2. Thus, it might be concluded that amylase formation by the cells, at least in the absence of nitrogen source, occurs only when extremely moderate metabolism is going on with nucleic acid as well as the carbon source.

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Incorporation of Phosphorus-32 into Salivary-type Chromosomes which exhibit 'Puffs'

A PRELIMINARY study has been made of the rate of incorporation of phosphorus-32 into the chromosomes and associated structures in the salivary gland of a Chironomid, *Metriocnemus hygropetricus*, and since there will be no immediate opportunity to carry the investigation further it seems worth while to present the results, which even at the present stage are not without interest. It has been shown by Prof. H. Bauer (who kindly made available some animals whose progeny were used for this study) that the salivary chromosomes of this species exhibit 'puffs' or Balbiani-rings of various kinds. Larvæ were grown on medium containing phosphorus-32 (as phosphate) for periods of 2–24 hr., and the incorporation was studied in autoradiographs of squashes and sections, which were stained with methyl-green-pyronin and in some cases extracted with ribonuclease or hydrochloric acid.

Both the nucleolus and the puffs stain bright red with pyronin, while the bands in the chromosomes stain with methyl-green; the pyronin staining disappears after ribonuclease digestion. Incorporation of tracer was adequate after feeding the larvæ on labelled medium for 4–8 hr., when the grain counts per unit area over the various components were:

	Cytoplasm	Puffs	Rest of chromosome	Background
4 hr.	$14{\cdot}2 \pm 1{\cdot}4$	$36{\cdot}2 \pm 2{\cdot}1$	$4{\cdot}9 \pm 1{\cdot}0$	$2{\cdot}7 \pm 0{\cdot}1$
8 hr.	$33{\cdot}7 \pm 2{\cdot}4$	$61{\cdot}4 \pm 2{\cdot}7$	$6{\cdot}1 \pm 0{\cdot}8$	$4{\cdot}6 \pm 0{\cdot}5$

The figures for 4-hr. exposures were taken from 10 cells belonging to 3 larvæ, and those for 8 hr. from 20 cells from 5 larvæ. Nearly all the activity was removed from cells treated with ribonuclease or hydrochloric acid. It is clear that the puffs are very much more active per unit area of squash than the remainder of the chromosomes, which show an incorporation very little above the background. It is not obvious what would be the relative activities of the two types of structure if one used the content of ribonucleic acid as the basis of comparison, since the staining reactions show that this substance is much more highly concentrated in the puffs (and somewhat more in the cytoplasm) than it is in the remainder of the chromosomes.

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Demonstration of Early Renal Uptake of Potassium-42 by an Autoradiographic Method for Water-soluble Isotopes of Short Half-life

STUDIES of the distribution of intravenously injected potassium-42 in rats have shown that the kidney takes up this cation from the plasma at considerably higher rates than does any other organ[1,2]. In the first few minutes after the injection, the specific activity in the renal tissues exceeds that of the plasma[1,2]. At 2 min., approximately 15 per cent[1] and 10 per cent[2] of the injected dose were found in rabbit kidneys and about 12 per cent (unpublished observations) in rat kidneys. These fractions are far greater than the expected equilibrium value. Analysis of these findings indicated that all the potassium arriving in the plasma in the kidney is exchanged with potassium from cells. Morel and Guinnebault have recently presented evidence that the renal cortex is the main site of this very rapid exchange[3]. From their experiments it appears that in the rabbit as much as 15 per cent of the total potassium present in the cortex is exchanged per minute. This was corroborated macroscopically by autoradiography in which X-ray films were exposed to 2-mm. thick frozen kidney slices. The resulting autoradiograms indicated that in the 5 min. following an intravenous injection, the intense activity emanated from a region roughly corresponding to the cortex.

The purpose of the present experiments was to obtain information microscopically about the difference in potassium-42 uptake in the various parts of the nephron. Potassium-42 bicarbonate, the chosen carrier, is highly soluble in water. This prevented the use of the traditional histological techniques. Freeze-drying followed by vacuum-embedding was precluded by the short half-life of the isotope (12·4 hr.), no useful exposure of photographic emulsion being possible after three half-lives. The technique described below circumvented these limitations.

After the intravenous injection of 25–100 μc. of potassium-42 into rats, their kidneys were excised at 2 min. and sections prepared for autoradiography or by Gomori's alkaline phosphatase technique[4]. Slices 1–2 mm. thick were promptly transferred into absolute acetone, in which they were fixed for 30 min. This was immediately followed by immersion in polyethylene glycol ('Carbowax 1000') at 44° C. for 1 hr., the shortest period found to allow complete infiltration. The tissues were then blocked in 'Carbowax 1000' and hardened at 3° C. Chemically clean slides were coated with an aqueous solution of 0·0001 per cent chrome alum and 0·005 per cent gelatin, and dried in a dust-free atmosphere. These slides were then flooded with acetone and 10-μ sections floated on to them. With acetone, the surface tension effects which cause disruption of 'Carbowax' sections when flattening is attempted on aqueous solutions did not occur. Acetone also ensured removal of 'Carbowax' without loss of potassium-42.

Groups of three adjacent sections were treated in two ways. The use of Gomori's alkaline phosphatase technique on the first and third section of a group allowed definite identification of proximal convoluted tubules. The middle section was used for autoradio-

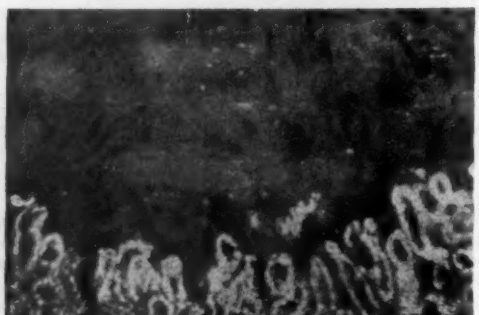

Fig. 1. Autoradiogram showing distribution of potassium-42 activity in juxtamedullary cortex. There is no evidence of medullary activity. Silver grains in emulsion showing as bright specks. Dark-ground illumination. × 50

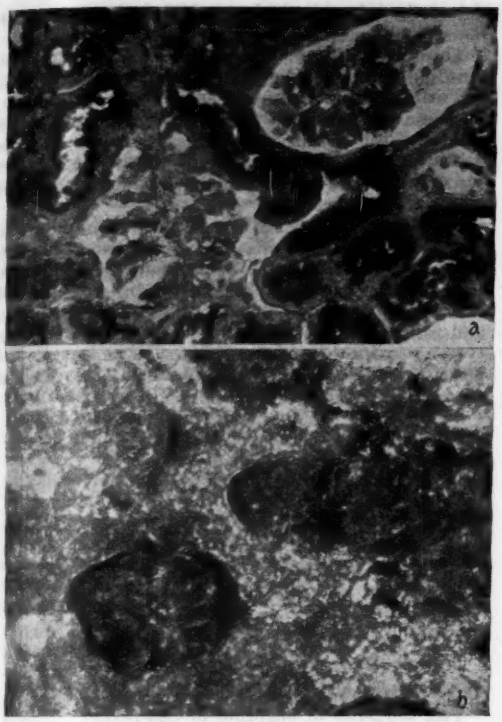

Fig. 2. (*a*) Alkaline phosphatase preparation of kidney cortex. Proximal convoluted tubules dark. Light microscopy. × 130. (*b*) Autoradiogram showing distribution of potassium-42 activity in corresponding site of adjacent section. Dark-ground illumination. × 120. Note that the highest radioactivity arises from proximal tubules

graphy. The latter sections were next covered with a 1 per cent solution of 'Perspex' in chloroform. Rapid drying resulted in a thin, uniform layer impermeable to water over the sections. 'Kodak Autoradiographic' stripping film was then wrapped around the slide[6]. After drying in a current of air, the preparations were exposed for three half-lives (approximately 37½ hr.) in darkness over a desiccant (calcium chloride). After mounting in Farrant's medium, the sections were examined by light-, phase- and darkground-microscopy. With this technique it is possible to start exposure four hours after excision of the organ.

Autoradiograms so prepared showed evidence of considerable activity in the cortex but very little in the medulla (Fig. 1). Some regional differences in distribution were found in the cortex, inasmuch as the juxtamedullary part showed more uniform radioactivity than the more peripheral parts. When the various segments of the nephron were compared, the highest activity was found in cells of the proximal convoluted tubules. Comparison of autoradiograms with appropriate areas of adjacent Gomori preparations confirmed this observation (Fig. 2, *a*, *b*). In any single section through a tubule, activity was equally present in all cells. This was true of tubules of regions of both high and low activity. Where cytological localization was possible, the potassium-42 was frequently associated with the basal part of the tubular cells. This region contains the mitochondria. The activity was less frequently associated with the region about the brush border and rarely distributed throughout the whole cell.

It seems that this use of acetone does not allow gross leaching of potassium-42 in cells. On the other hand, potassium present in urine and plasma is removed to a large extent and so does not mask activity emanating from intracellular locations.

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Tyrosine Peptides as Precursors of Melanin in Mammals

The important role of mammalian tyrosinase in the formation of melanin has been convincingly demonstrated[1]. In all earlier studies, tyrosine has been thought to be the only effective substrate, with the exception of tyrosine ethyl ester which was found by Lerner *et al.*[2] to be oxidized by Harding–Passey melanoma tyrosinase preparations. In a few cases, tyrosine peptides have been investigated as potential substrates, and Bloch[3] found that human skin extracts could not oxidize glycyl-dihydroxyphenylalanine, while Kertész[4] reported that glycyl-L-tyrosine was not oxidized by tyrosinase preparations obtained from human melanomas. Lerner[1] predicted that tyrosine peptides in which tyrosine occupies the *N*-terminal position would be substrates of mammalian tyrosinase, but that tyrosine peptides in which tyrosine occupied the *C*-terminal position would not.

I have been investigating the action of mushroom and mammalian tyrosinase preparations on tyrosine peptides. Early in this work, it became clear that the oxidative activities of the two tyrosinase preparations toward tyrosine peptides were quite different. While L-tyrosyl-glycyl-glycine was oxidized by mushroom tyrosinase, it was not oxidized by mammalian tyrosinase. A number of other tyrosine peptides, including the hormones glucagon, beta-corticotropin, oxytocin and vasopressin, have been studied, using mushroom tyrosinase. Although sufficient amounts of all the hormones were not available, from the peptides and hormones tested, the oxygen uptake was less than five atoms of oxygen per molecule of substrate. However, with mammalian tyrosinase, regardless of the position of the tyrosine residue, an uptake of five atoms of oxygen per molecule of peptide was observed. The nature of the product formed was also quite different. With mammalian tyrosinase an insoluble melanin was formed, whereas with mushroom tyrosinase a soluble polymer formed. Fig. 1 shows the oxygen uptake observed when Harding–Passey melanoma tyrosinase (kindly supplied by Dr. A. B. Lerner) was incubated with (*A*) L-leucyl-L-tyrosine, (*B*) L-tyrosyl-glycine, (*C*) tyrosine, and (*D*) no substrate. In each case, 1 ml. of phosphate buffer (0·1 *M*, *p*H 6·8), 1 ml. of substrate (2·76 micromoles), 0·3 ml. of water, 0·2 ml.

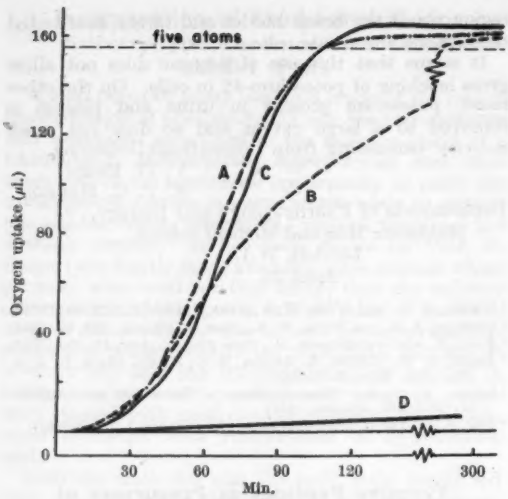

Fig. 1

of 20 per cent potassium hydroxide (centre well), and 0·5 ml. of Harding–Passey melanoma tyrosinase (15 mgm.) were added to each flask and the oxygen uptake measured at 37° C.

The results with mammalian tyrosinase preparations indicated that either the tyrosine peptides were being oxidized intact, or they were being hydrolysed by peptidases to the free amino-acid. To determine which was the case, the reaction mixtures at the end of the manometric experiments were added to 'Dowex-50' (acid form), which would take up any amino-acids present. The resin was then washed, eluted with 5 *N* ammonium hydroxide, and the eluate taken to dryness and chromatographed, using the upper phase of the solvent system *n*-butanol/acetic acid/water (4 : 1 : 5). In each case, free amino-acids were detected corresponding to those which, with tyrosine, formed the peptides. These results demonstrate that there must be a peptidase present which is hydrolysing the tyrosine peptides. Therefore, the reaction sequence with mammalian tyrosinase preparations is as follows :

(1) Tyrosine peptide $\xrightarrow{\text{Peptidase}}$ tyrosine + amino-acid

(2) Tyrosine $\xrightarrow{\text{Tyrosinase}}$ melanin

It must be kept in mind that mammalian tyrosinase is located within melanin granules, and no method has been found which will solubilize the tyrosinase. The peptidases may be within the melanin granules or may be closely associated with them. When the reaction mixtures resulting from the oxidation of the peptides, using mushroom tyrosinase, were chromatographed, no free amino-acids were detected, demonstrating that the peptides were oxidized intact.

Also, evidence has been obtained that esterases are present in the Harding–Passey melanoma tyrosinase preparations, since the total oxidation observed when using mushroom and mammalian tyrosinases are different when tyrosine ethyl ester is used as a substrate. Four atoms of oxygen uptake per molecule of substrate were observed with mushroom tyrosinase, whereas five atoms were observed with mammalian tyrosinase. Experiments are being conducted to detect the ethanol which should be a product of the reaction, if esterases are present.

Thus, it has been shown for the first time that Harding–Passey melanoma tyrosinase preparations can utilize tyrosine peptides as precursors of melanin. Tyrosinase oxidizes the tyrosine which is formed as a result of the action of peptidases on the tyrosine peptide. This work also supports the view that tyrosine is the only monophenolic substrate of mammalian tyrosinase.

Further work is being carried out on the substrate specificity of the peptidase. No detailed studies on peptidases which hydrolyse tyrosine peptides have been reported in the literature. Other sources of mammalian tyrosinase such as the human melanoma and retina have been studied for their ability to use tyrosine peptides as precursors of melanin, and positive evidence has been obtained. A detailed report of this work will be published.

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Tooth Eruption Sequence in Fossil and Recent Man

The sequence of eruption of the permanent teeth has been used as a measure of the biological distance between early and recent man. Schultz[1] gives the order $M_1\, I_1\, I_2\, M_2\, (P\, P)\, (C\, M_3)$ for fossil man, as contrasted with $(I_1\, M_1)\, I_2\, (P\, C\, P)\, M_2\, M_3$ for recent whites, a distinction in which Osman-Hill[2] concurs. Broom and Robinson[3] have further used the sequence $I_1\, M_1\, I_2\, (C\, P_1)\, M_2\, P_2\, M_3$ as a taxonomic criterion for *Paranthropus*, holding that this sequence "agrees closely with that of modern man".

Understandably, the eruption sequences given for the fossils are estimates, with the assumption (usually unstated) that the order of eruption in skeletalized material is equivalent to the order of eruption as seen in the living, and further, that the developmental stages of the teeth provide a reliable indication of the order of eruption.

A study of the dental development of more than 200 white American-born children at the Fels Research Institute, utilizing serial röntgenological and clinical records, shows that the course of dental development is a most variable phenomenon[4]. It was found that the various stages are at best only moderately correlated with each other. Moreover, the eruption of a tooth from the alveolus is by no means comparable to cutting through the gum. Throughout the growth period, the order of development of a given pair of teeth may become reversed and reversed again. In fact, between emergence from the alveolus and the time that the occlusal level is reached, a reversal of sequence may take place. This applies especially to the premolars and to the second molar, which in turn is nearly at the occlusal level before cutting the gum.

It appears that many of the published statements concerning the tooth eruption sequence in fossil man are incorrect, due in part to lack of knowledge of

the course of dental development. Weidenreich[5] erroneously assigned the M_2P_2-sequence to *Sinanthropus* on the basis of the location of developing teeth still embedded in the jaw. But the published radiographs of the mandible *B–I* show that the stage of calcification of these two teeth is identical. Judging further from the relationship of the deciduous molar to the underlying second premolar in *B–I*, the eruption sequence in the *Sinanthropus* child would more likely have been P_2M_2. Again, in view of the findings stated in the previous paragraph, there is no conclusive evidence that the Krapina[6], Le Moustier[7], Ehringsdorf[8] and Afalou[9] children would have been M_2P_2. But the assignment of a probable P_2M_2-eruption sequence in the Teshik-Tash child[10] does appear reasonable. Finally, the sequence already given for the South African fossils cannot serve to align them positively with recent man or fossil man.

While it is now doubtful that the M_2P_2-sequence was characteristic of fossil man, it is noteworthy that the M_2P_2 order of eruption through the gum is not uncommon in contemporary peoples. It exists in 16 per cent of Finnish children, as determined at the Finnish Centre for Research in Child Growth and Development, and in the majority of Pima and Apache children examined by Hrdlička[11] half a century ago. Even the M_2C-sequence occasionally appears. Thus the eruption sequence for modern man may well be rewritten as : $(M_1I_1)\,I_2(C\,P_1\,P_2\,M_2)\,M_3$, indicating the great deal of variability that does, in fact, occur.

Thus no essential difference has as yet been shown between the eruption sequences of the permanent teeth in fossil and modern man. Therefore, any attempt to utilize the order of eruption as a taxonomic criterion, even assuming that the order was correctly ascertained, is fraught with danger[12,13].

We are greatly indebted to Dr. Arthur B. Lewis, who has maintained the longitudinal collection of dental radiographs at the Fels Research Institute since 1939, and to Mr. Demarest Polacheck for skilful technical assistance.

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Partial Albinism in the Syrian Hamster

DURING 1954, and also in 1955, a new mutant white hamster was imported from the United States. The adult mutant possesses pink (pigmentless) eyes and a white pelage but with dark (pigmented) ear pinna. The pigment is dark (melanin) and resides in the skin, the hair on the ears being white. Pigment is also present in the skin of the prepuce (as spots) and in the scrotum of males; and in the perineum region of females. The amount of pigment in the ear appears comparable to that present in the normal golden hamster; but the amount in the genital regions is reduced. The young hamster at twenty-one days of age is devoid of skin melanism, with flesh-pink ears. By twenty-six days of age (range 24–28 days) the ears are distinctly tinged with pale grey. By the thirty-first day the ear colour is grey; thereafter the ear darkens more slowly, eventually becoming black. Some 2–3 months may elapse before pigment is manifested in the genitals. These observations strongly suggest that the phenotype is that of a thermo-sensitive acromelanic albino (such as the Himalayan rabbit or Siamese cat). The symbol c^d is proposed for the mutant allele.

Preliminary experiments determined that the allele is inherited as a recessive. Reciprocal crosses of normal × albino gave a normal F_1 and an F_2 segregation of sixty-nine normal and twenty-five albino ($\chi_1^2 = 0{\cdot}128$; $P > 0{\cdot}70$). Recently, the results of two extensive series of matings have been completed. The first of these has yielded an F_2 segregation of 1,019 normal and 356 albino ($\chi_1^2 = 0{\cdot}582$; $P > 0{\cdot}30$). The second series produced an F_2 generation of 476 normal and 143 albino ($\chi_1^2 = 1{\cdot}190$; $P > 0{\cdot}10$). Heterogeneity between the three groups is negligible ($\chi_2^2 = 1{\cdot}890$; $P > 0{\cdot}10$). No association was found to exist between partial albinism and sex ($\chi_1^2 = 1{\cdot}397$; $P > 0{\cdot}20$).

The second series of matings were designed to test for linkage between c^d and *ru* (the latter a ruby-eye mutation reported earlier[1]). The F_2 generation from $c^dRu/Cru \times c^dRu/Cru$ gave the following distribution.

CRu	*Cru*	c^dRu	c^dru
394	82	123	20

There is a deficiency of *ruru* animals; but this phenotype is known to be sub-viable compared with the normal hamster. However, the four classes analysed as a 2 × 2 table do not disclose an association between the simultaneous segregation of the two alleles ($\chi_1^2 = 0{\cdot}839$; $P > 0{\cdot}30$). It may be noted that the estimate of viability of *ruru* zygotes for the present data ($0{\cdot}5919 \pm 0{\cdot}0702$) does not differ significantly from that previously reported ($0{\cdot}4773 \pm 0{\cdot}0869$).

An interesting item from this segregation is the appearance of a 'synthetic albino'. The phenotype c^dc^druru possesses pink eyes and white fur but also flesh-coloured ears and genitals. This is the result of the mutual action of the two genes. The ruby-eye hamster has peach-grey ears and little or no melanin about the perineum. The ear colour of the synthetic albino varies from clear flesh-pink to peach-grey but not apparently attaining the same degree of peach-grey found in the ruby-eye. The reason for this is not obvious; but it is implicit that the thermal threshold of pigment production in c^dc^druru animals may be higher than that in *C-ruru*.

I wish to thank Mr. G. T. C. Gore for kindly recording the data for the first series of matings.

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Experimental Studies of Mimicry in some North American Butterflies

Experiments have been conducted to test the effectiveness of presumed mimicry in two groups of North American butterflies: (1) *Danaus plexippus* Linn. (model) and *Limenitis archippus archippus* Cram. (mimic), the monarch and viceroy respectively; (2) *Battus philenor* Linn. (model) and *Papilio troilus* Linn., *P. polyxenes* Stoll, and *P. glaucus* Linn. (black female) (mimics).

Eight caged Florida scrub jays (*Cyanocitta coerulescens coerulescens* Bosc) were used as predators in feeding experiments in which they were given presumed models and mimics, as well as non-mimetic butterflies. For the purpose of this communication, non-mimetic butterflies are those butterflies which are not involved in mimicry either as mimics or models. These studies were carried out at the Archbold Biological Station in southern Florida in the spring of 1956. The same individual birds, with the exception of one, were used throughout both groups of experiments, which were carried out in the order listed above.

After preliminary tests with various orders of insects to accustom the eight birds to laboratory conditions, four were randomly selected as experimental birds; the remaining four were control birds. Throughout the experiments each butterfly, if alive, was immobilized by pinching the thorax before it was given to a bird. Each butterfly was placed in a lateral position on the floor of the cage, and each bird was allowed a total of 2 min. to react to each butterfly given. The treatment of each butterfly by each bird was recorded according to four categories: (1) not touched; (2) pecked, but not injured; (3) killed or injured, but not eaten; (4) eaten. A total of 2,508 butterflies was given to the birds in the course of these experiments. The following procedure was used in the experiments with both mimicry complexes.

Experimental birds: (*a*) Each experimental bird was given approximately fifty trials with models; and with non-mimetic butterflies which were shown in the preliminary tests to be palatable to all the birds. Each trial consisted of the presentation of two butterflies: one model and one non-mimetic butterfly. The order of presentation of these in any given pair was determined with a table of random numbers.

(*b*) After the fifty initial trials with models and non-mimetic butterflies, the experimental birds were given mimics in place of models.

Control birds: The control birds were given mimics and non-mimetic butterflies; the same species of non-mimetic butterflies and the same method of presentation described for the experimental birds were used. The control birds were never given models.

The results showed that the non-mimetic butterflies were eaten in every case by all eight birds throughout all the experiments. It was found that the experimental birds, after they had pecked models in the first few trials, would 'not touch' models on sight alone in 205 out of 339 trials (60 per cent) for *D. plexippus*, and in 161 out of 209 trials (77 per cent) for *B. philenor*. The experimental birds ate none out of 339 (0 per cent) *D. plexippus* given to them, and only 2 out of 209 (1 per cent) *B. philenor*. When mimics instead of their models were offered in later trials with these experimental birds, the 'not touched' treatment of mimics was as follows: 42 out of 60 trials (70 per cent) for *L. a. archippus*; 27 out of 41 trials (66 per cent) for *P. troilus*; 12 out of 13 trials (92 per cent) for *P. polyxenes*; and 6 out of 12 trials (50 per cent) for *P. glaucus* (black female). The experimental birds ate none out of 60 (0 per cent) *L. a. archippus* presented; 9 out of 41 (22 per cent) *P. troilus*; 1 out of 13 (8 per cent) *P. polyxenes*; and 3 out of 12 (25 per cent) *P. glaucus* (black female).

In contrast to the experimental birds, the control birds, having had no laboratory experience with models, did 'not touch' the mimics in only 10 out of 100 trials (10 per cent) for *L. a. archippus*; none out of 392 trials (0 per cent) for *P. troilus*; none out of 40 trials (0 per cent) for *P. polyxenes*; and none out of 12 trials (0 per cent) for *P. glaucus* (black female). Moreover, the control birds ate the mimics in 60 out of 100 trials (60 per cent) for *L. a. archippus*; 392 out of 392 trials (100 per cent) for *P. troilus*; 39 out of 40 trials (98 per cent) for *P. polyxenes*; and 12 out of 12 trials (100 per cent) for *P. glaucus* (black female).

The results given above are lumped for all the experimental birds, and for all the control birds. It should be remembered that, in experiments with caged predators, the predator is actually afforded a closer and longer scrutiny of a model or mimic than would usually be possible under natural conditions, where an attacking bird might get only a glimpse of a flying butterfly.

The treatment ('not touched' *vs.* 'pecked–killed–eaten', and 'not touched–pecked–killed' *vs.* 'eaten') of the mimics (*L. a. archippus*, *P. torilus* and *P. polyxenes*) by the experimental and control birds was analysed with the chi-squared test on the hypothesis, in each case, that both sets of birds treated the mimics the same; the calculated values for P were less than 0·001. The significant difference in treatment is attributed to the fact that the experimental birds had about fifty initial trials with each model before experiencing the mimic; the colour pattern of the model, in each case, was associated with the learned unpalatability of that butterfly. Then when the mimics were presented, the experimental birds in general were unable to discriminate the colour pattern of the mimic from that of the model. Under the conditions of the experiment, the effectiveness of mimicry in the case of *L. a. archippus*, and of *P. troilus* and *P. polyxenes* has been demonstrated.

Full results and an extended discussion of these experiments and others will appear elsewhere at a later date. This work was aided by a Fanny Bullock Workman Scholarship from Wellesley College and a National Science Foundation terminal predoctoral fellowship.

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Status of *Moerisia lyonsi* Boulenger and Related Hydroids

Last year, when considering evolutionary trends in capitate hydroids and medusæ[1], I was astonished by the remarkable similarity between some of these forms (*Euphysa* hydroids and *Sarsia* medusæ) and the hydroid and medusa of *Moerisia lyonsi* Boulenger[2]. The latter and related species of the family Moerisiidae have for some time been placed in the Limnomedusæ[3], an order which includes such diverse forms as *Proboscidactyla* (*Lar*, the posturing polyp of Gosse) and *Craspedacusta* (the freshwater medusa).

Consideration of the important features of the Moerisiidae common to other Limnomedusæ revealed these were: a quadrate stomach, tentacles which were either hollow or had an endodermal core consisting of more than a single row of cells, and the semblance of an endodermal root in the tentacles of the medusa[4]. These characters in themselves are not enough to warrant the separation of the Moerisiidae from the Capitata (with which their morphological characteristics strongly suggested they belonged) and I sought for additional links with other Limnomedusæ. It was thought that the cnidome (the nematocyst armature) might reveal more positive evidence in favour of Limnomedusan affinities, but the three best-known species[5] have a tricnidome consisting of stenoteles, desmonemes and atrichous haplonemes[6]. This grouping of nematocyst types is essentially a capitate one, which is, moreover, distinct from the nematocyst pattern in the other two Limnomedusan families. The quadrate stomach of the medusa cannot be regarded as more than a variant of the basic pattern seen in the Capitata as its gonad is continuous and unbroken. The other two characteristics mentioned could arise independently in almost any family of medusæ, and are probably far less significant than evidence based on nematocysts. For these reasons, which will be more fully discussed elsewhere, the family Moerisiidae is placed in the sub-order Capitata of the order Anthomedusæ.

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Stimulation of Sclerotium Germination in *Sclerotium cepivorum* Berk.

Earlier work by Scott[1] demonstrated the inability of *S. cepivorum*, the cause of white rot disease of onions, to grow or survive, in soil, in the form of mycelium, and focused attention on the biology of its sclerotia, which are produced in large numbers on the base of infected plants.

Sclerotia from cultures grown for six weeks on sand – maize-meal slopes at 20° C. were shown to persist in undisturbed field soil for at least three years in the absence of the host plant. Using as inoculum sclerotia which had been buried for less than two months in soil, no infection occurred but there was heavy infection of onion seedlings inoculated with sclerotia which had been buried for longer periods.

Table 1. Percentage Germination of Sclerotia in Soil and Sand with or without Onions

Medium	Water holding capacity (per cent)	With (+) Without (−) onions	Germination (per cent)
Soil	60	+	83·3
,,	60	−	0·0
,,	40	+	64·6
,,	40	−	0·0
Sand	60	+	62·5
,,	60	−	0·0
,,	40	+	45·8
,,	40	−	0·0

Accordingly, sclerotia used in germination experiments were taken from soil after six months burial.

Onion seedlings were inoculated, before being transplanted singly into tubes of soil, at 40 and 60 per cent water-holding capacity, by placing a sclerotium between the roots at the base of the bulb. On lifting the infected plants it was possible to see that the sclerotia had germinated characteristically by the formation of a plug of hyphæ which emerged after the rupture of the rind. In experiments of this kind levels of germination of sclerotia averaged 60–92 per cent, whereas in the control tubes without onions, germination was usually 0 per cent, and, rarely, up to 15 per cent.

In further experiments, moist nylon strips measuring 11 cm. × 2·5 cm. were placed inside 4 in. × 1¼ in. glass specimen tubes, in contact with the glass, near the top. Sclerotia were placed in a ring between glass and nylon at the rate of twelve sclerotia per tube. In half the tubes twenty-four white Lisbon onion seeds were similarly placed 1 cm. above the sclerotia. Soil or sand was then added to the tubes and kept at a constant water-holding capacity, at laboratory temperature. After eight weeks the levels of sclerotium germination were recorded (Table 1). Each value is an average of four replicates.

That the stimulatory effect of onions was not dependent upon contact between sclerotium and root was indicated by the fact that many of the germinating sclerotia were up to 1 cm. distant from onion roots.

Using onion seedlings which were germinated on moist filter paper in Petri dishes, 100 per cent germination of sclerotia occurred when they were placed in contact with any part of roots which had previously been damaged by needle pricking. On undamaged roots there was 97·5, 47·5 and 57·5 per cent germination of sclerotia placed, respectively, on root tips halfway between tip and base, and on base of bulb. Sclerotia placed on moist filter paper in Petri dishes did not germinate.

The addition of water extracts of roots of onion, shallot, and leek also had a marked stimulatory effect on the germination of sclerotia in soil. Quoting the results of one particular experiment, average germination figures of 86·7, 93·3 and 73·3 per cent were obtained, respectively, with extracts of onion, shallot and leek. No germination occurred, however, using extracts of roots of cabbage, brussels sprout and barley, or when distilled water alone was added.

These investigations are proceeding with the object of isolating and identifying the stimulatory substance.

J. R. Coley-Smith
C. J. Hickman

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[1] Scott, M. R., *Ann. App. Biol.*, **44**, (4), 576 (1956).

FORTHCOMING EVENTS

Wednesday, September 4

Institute of Petroleum (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. A. Kranendonk (N.V. De Bataafsche Petroleum Mij.): "Some Developments in Marine Drilling Foundations".

Wednesday, September 4—Wednesday, September 11

British Association for the Advancement of Science (at Dublin).—Annual Meeting.

Wednesday, September 4

At 7.30 p.m.—Prof. P. M. S. Blackett, F.R.S.: "Technology and World Advancement" (Presidential Address).

Thursday, September 5

At 10 a.m.—Prof. J. Z. Young, F.R.S.: "The Evolution of Organization in the Nervous System" (Presidential Address, Section D).

At 10 a.m.—Prof. Sir Lindor Brown, F.R.S.: "Chemical Transmission at Nerve Endings" (Presidential Address, Section I).

At 10 a.m.—Prof. J. Doyle: "Aspects and Problems of Conifer Embryology" (Presidential Address, Section K).

At 10 a.m.—Sir James Turner: "The Role of Agriculture in the British Economy" (Presidential Address, Section M).

At 11.15 a.m.—Mr. T. McEvoy: "Forestry in Ireland" (Chairman's Address, Section K*).

At 11.30 a.m.—Dr. J. W. Cook, F.R.S.: "Chemical Approaches to the Investigation of Lung Cancer" (Presidential Address, Section B).

At 11.30 a.m.—Prof. J. E. Meade: "The Balance-of-Payments Problems of European Free Trade" (Presidential Address, Section F).

At 11.30 a.m.—Dr. H. G. Maule: "The Worker and his Work" (Presidential Address, Section J).

At 2.15 p.m.—Prof. C. F. C. Hawkes: "Archæology as Science: Purposes and Pitfalls" (Presidential Address, Section H).

At 2.15 p.m.—Prof. D. A. Webb: "The Vasculum and the Microtome—the Relationship between Natural History and Laboratory Biology" (Presidential Address, Section X).

At 8 p.m.—Mr. G. F. Mitchell: "Ireland in Antiquity: the Chronological Background" (Evening Discourse).

Friday, September 6

At 10 a.m.—Prof. T. G. Cowling, F.R.S.: "Stellar Energy and Stellar Evolution" (Presidential Address, Section A).

At 10 a.m.—Sir David Anderson: "Education and Training for the Engineering Industry" (Presidential Address, Section G).

At 11.30 a.m.—Prof. David L. Linton: "The Everlasting Hills" (Presidential Address, Section E).

At 11.30 a.m.—Mr. L. R. Missen: "The Education of the Countryman" (Presidential Address, Section L).

At 8 p.m.—Dr. H. J. Bhabha, F.R.S.: "On the Economics of Atomic Power Development in India and the Indian Atomic Energy Programme" (Evening Discourse).

Sunday, September 8

At 11.15 a.m. (in St. Patrick's Cathedral)—Religious Service. Preacher: The Lord Archbishop of Dublin.

Monday, September 9

At 10 a.m.—Dr. G. H. Mitchell, F.R.S.: "Ordovician Volcanoes" (Presidential Address, Section C).

At 8 p.m.—Sir Sydney Caine: "Education for Development".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant, Grade B, in the Mathematics Department, to teach Mathematics (Pure and Applied) to the level of the higher national certificate and B.Sc. General Degree Part I—The Principal, Derby and District College of Technology, Normanton Road, Derby (September 7).

Head (with a good honours degree in physics, together with a research degree, the Fellowship or Associateship of the Institute of Physics and teaching experience, preferably in a technical college or university) of the Physics Department—The Principal, Wigan and District Mining and Technical College, Wigan (September 7).

Senior Lecturer (with a degree in physics, and industrial, research and teaching experience, and preferably a special interest in some branch of applied physics) in Physics—The Clerk to the Governing Body, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3 (September 7).

Miles Ames Fellow (with a Ph.D. degree or equivalent in chemistry, biochemistry or an allied subject) in Endocrinology, to carry out original work on steroid hormones or on any other aspect of endocrinology in which he or she is particularly competent—The Secretary, King's College Hospital Medical School, Denmark Hill, London, S.E.5 (September 14).

United Steel Companies' Research Fellow (with some research experience) in the Department of Metallurgy, to work on the purification of iron by zone melting and to make a systematic study of the properties of high purity iron and its alloys—The Registrar, The University, Sheffield (September 16).

Hydrologist (with a university honours degree or equivalent with chemistry as a major subject, and some physics and mathematics and postgraduate research experience, preferably in a marine hydrological laboratory) in the Division of Fisheries and Oceanography, Commonwealth Scientific and Industrial Research Organization, Sydney, New South Wales, to take part in a research programme on the chemistry of Australian coastal waters—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 320/128 (September 21).

Director (with suitable qualifications and considerable experience in museum work) of City Museums—The Town Clerk, Civic Hall, Leeds 1 (September 30).

Gum Research Officer (with a thorough knowledge of forestry, an appropriate university degree, and experience in tropical forestry and research work and modern sylvicultural practices) in the Forestry Department of the Ministry of Agriculture, Sudan—Sudan Embassy, Personnel Section, Cleveland Row, St. James's, London, S.W.1, quoting Ref. "Gum Research Officer 4/445" (September 30).

Senior Lecturer in Theoretical Aerodynamics—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks (September 30).

Senior Lecturer (with a Doctorate of Philosophy or Science conferred for research in some branch of physics, and preferably some lecturing experience) in Physics, at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

Chair of Applied Mathematics—The Registrar, University College of Wales, Aberystwyth (October 7).

Research Assistant (with a good honours degree in physics and some postgraduate experience in high vacuum work) in the field of Vacuum Spectroscopy—Prof. R. W. Ditchburn, The University, Reading (October 15).

Reader in Geophysics at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 15).

Biochemist, Basic grade (with a first- or second-class honours degree in chemistry or biochemistry)—The Medical Superintendent, Royal Infirmary, Glasgow, C.4.

Geophysicist (preferably single, with an honours degree in geology or physics and a good knowledge of magnetometer survey) with the Falkland Islands Dependencies Survey, for service in the Antarctic for eighteen months under conditions which are a test of character and resource—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.3B/44252/NF.

Instructor or Assistant Professor (with the Ph.D. degree or equivalent) in Entomology—Prof. I. McT. Cowan, Department of Zoology, University of British Columbia, Vancouver, B.C., Canada.

Laboratory Steward in the Chemistry and Biology Department—The Registrar, College of Technology, Park Road, Portsmouth.

Lecturer, Assistant Professor, or Professor (with a Ph.D. degree and experience in teaching and research) in Bacteriology, at the College of Arts and Science, Baghdad, Iraq—The Cultural Attaché, Iraqi Embassy, 22 Queen's Gate, London, S.W.7.

Lecturer, Grade B (graduate of a British university, and preferably an interest in statistics or the industrial application of mathematics) in Mathematics—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

Scientific Officers (with a first- or second-class honours degree in appropriate scientific subjects, or equivalent qualifications, and preferably some knowledge of electronics) at the Atomic Weapons Research Establishment, Foulness, Essex, for the development and application of instrumentation for research on explosives and properties of materials under conditions of high pressures and temperatures, with opportunities for original design work in the solution of unusual problems—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1563/34.

Senior and Junior Research Fellows (with a first- or second-class honours degree in an appropriate subject, and able to show evidence of a very high standard of ability in research) at Government Scientific Establishments, for research into subjects of importance to H.M. Government—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S.4695/57.

Senior Technician (preferably with higher national certificate or equivalent qualifications) for electronics work in connexion with a 30 MeV. synchrotron and other projects—The Secretary, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3.

Systematic Botanist and Ecologist (with an honours degree in botany and at least two years research experience preferably in ecology; or an honours degree or equivalent in agricultural science plus two years completed postgraduate training in botany, preferably with an ecological bias) in Sierra Leone, to carry out ecological studies appertaining to agricultural and forestry field problems (including the maintenance and enlargement of a herbarium)—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD/63/15/012.

Zoo Superintendent (preferably with wide zoological and administrative experience)—The Secretary, Bellevue Zoological Gardens, Manchester 12.

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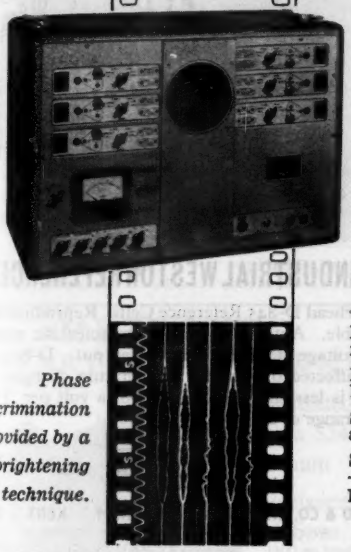

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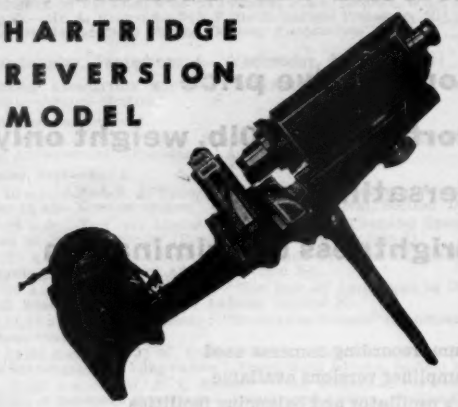

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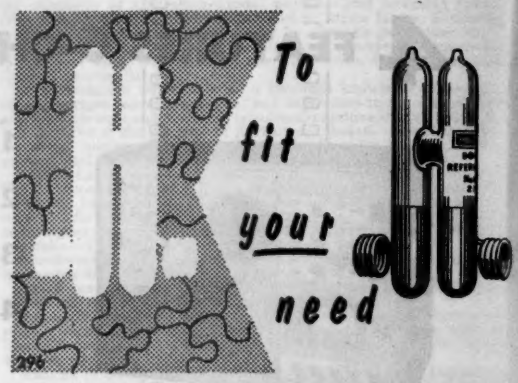

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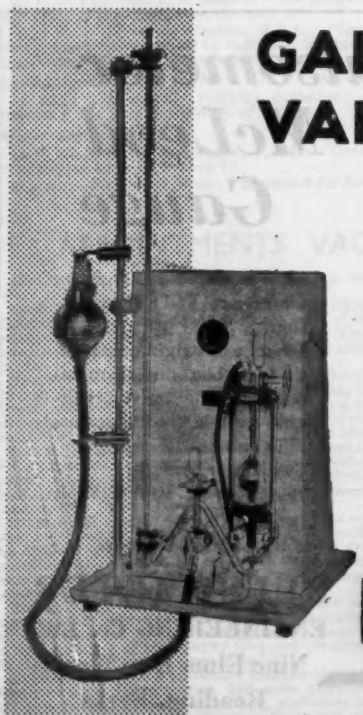

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